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LORD ARMSTRONG AND THE ELSWICK WORKS.

By Benjamin Taylor.

The Japanese Cruiser Naniwa, built at Elswick.

IN the "fairy tales of science and the long results of time" there is no more wonderful story than that of the industrial development of the world-renowned establishment which has grown up at Elswick, Newcastle-on-Tyne. "Armstrong's works," as they are popularly called, are the product of the last half of the nineteenth century, and they express the highest attainments of that unexampled era of progress. It is scarcely possible to exaggerate the influence which this mammoth establishment has had upon engineering, the manufacture of ordnance, and war-ship building. It is certainly not possible to exaggerate the social importance of it to the city of Newcastle-on-Tyne, and indeed to the whole district of Tyneside. Here are employed on the average an army of 25,000 workers, receiving every week something like £40,000 in wages to be spent and put in circulation in the neighbourhood. Here are turned out every

The Elswick works stand as the concrete revelation of the genius of their founder. In their intimate relation to naval expansion, in their sturdy conservatism in holding to the good until convinced of the better, and their splendid courage in progressive movement when convinced, they embody the dominant characteristics of British industry. Mr. Taylor discloses the spirit and method of the master-builder in the description of his work.—THE EDITORS.

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year millions of pounds' worth of steel and machinery, guns and shipping. The works, just on the western fringe of the city, have a river frontage upwards of a mile and a half long, from the steel works and ship-yards on the extreme east to the engine shops on the extreme west, with the foundries and ordnance department in between. All this has sprung from an idea which germinated in the fertile brain of a young Newcastle lawyer some sixty-five years ago. For Lord Armstrong, still the head of this great company, was born neither in the purple nor in the engine-room. He was only a country solicitor when he entered the battle of life, but he was endowed by nature with rare mechanical genius, with inventive faculty, and with phenomenal powers of penetration and foresight. When he went into engineering it was but a small works for making hydraulic machinery that he erected at Elswick, then a sort of rural retreat for Novocastrians. Opposite where now stands the great range of buildings of the Armstrong works was a long, low, verdant island called the "King's Meadow," sacred to the memory of picnics and boat-races. Many a famous race was "sculled" along that reach of shallow river, and many an aquatic contest has the present writer watched, as a boy, from points of vantage which he now seeks in vain to locate. Gone are the King's Meadow, the muddy, tide-forsaken shore, the shelving banks—gone with Harry Clasper and Bob Chambers and other heroes of the oar. The shallow stream is now a deep tidal river; in place of the swift out-rigger we find a wind-beating armoured cruiser; and for the cheers of the holiday crowd we have the ceaseless roar and hum of machinery. For one who can cast his mind's eye back even to the later sixties, the transformation at Elswick is marvellous. On the once more-or-less verdant banks he now finds a complete arsenal, more complete even than that of Woolwich or Essen; for at Elswick are made not only guns and projectiles of all sorts and sizes, but also the steel from which they are made, machinery of the highest types, and war-ships of all classes—everything, in fact, except gunpowder.

The engineering works date from 1847, having been commenced in that year by William (now Lord) Armstrong for the manufacture of hydraulic machinery. This is still a specialty of the establishment, though all sorts of engineering work is now done. The engineering works are at the west end of the establishment, and cover about 10 acres. Hydraulic cranes are the great feature of these works. You meet with them in all sizes and of many forms, but chiefly in three designs—all characterised by simplicity of mechanism and efficiency of action, fixed and movable, and with varying lifting

powers up to 160 tons. Here also is manufactured an immense amount of hydraulic machinery for docks, as, for instance, the gates for the Liverpool and Cardiff docks; hydraulic coal-shipping machines, which will lift 10-ton waggons a height of 30 feet and "tip" them down an iron chute in a minute and a half; hydraulic hoists of all sorts, capstans, pumps, winding engines, grain elevators, and other practical applications of water-power innumerable.

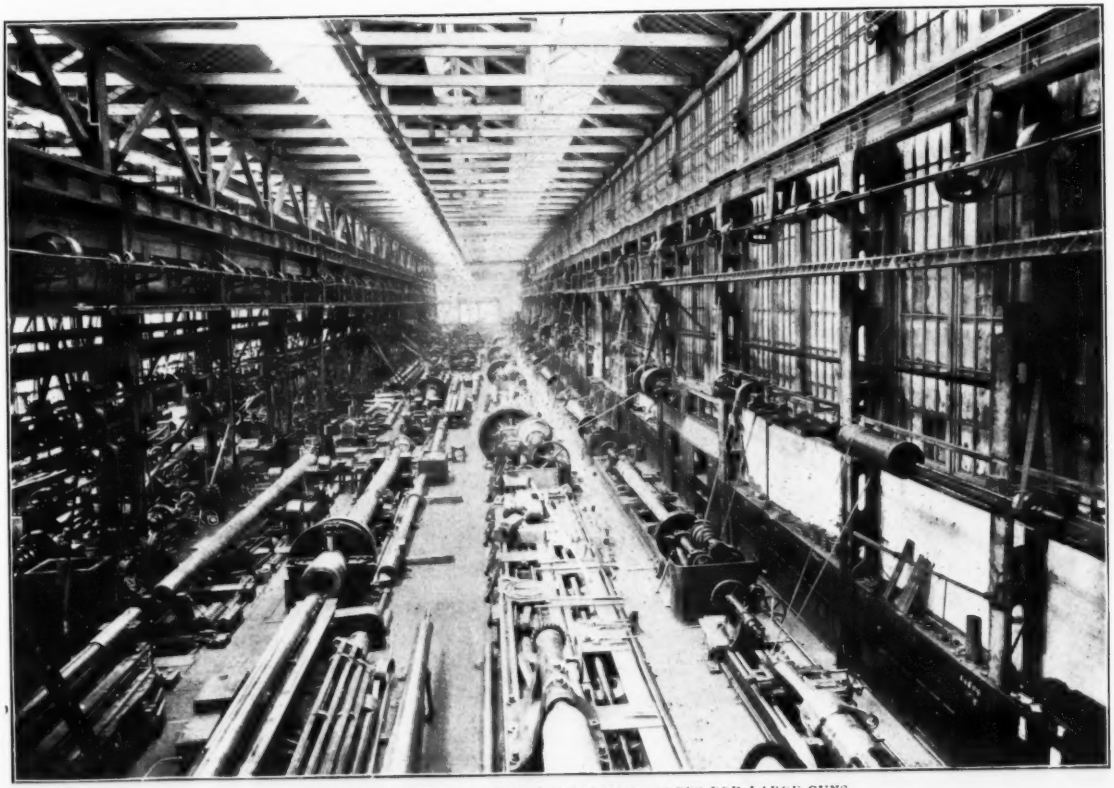
NO. 7 SHOP, ELSWICK WORKS.

Many famous bridges have been turned out from these works, including the remarkable swing-bridge between Newcastle and Gateshead, the construction of which enabled the Armstrong company to undertake the building of large ships at Elswick. The first hydraulic riveting machine was made here some forty years ago, and is still, I believe, in use.

Hydraulic power is naturally extensively used in the machine tools of these great shops, where the saving of labour is carried to the height of a fine art. A feature in connection with the engine works is the enormous brass foundry. This, however, is about to be transferred to the extension works which the company are erecting at Scotswood, to the west of the Elswick establishment, and when this is done the present brass-foundry building will be made into an erecting

shop. The Armstrong company do not as yet build marine engines. Some twelve years ago they put up a couple of large shops for the purpose, but such was the run on them for ordnance that they had to use the buildings as gun shops, and have never since been able to turn them to their original purpose. These two shops are larger than any other engine shops in the country, though whether an easing off in the demand for ordnance will ever permit the building of marine engines in them is problematic. The whole of the engineering department is now under the management of Mr. H. O. Rendel.

At the east end of the Elswick works were, until last year, three large blast furnaces for the smelting of hematite ore, producing iron at the rate of over 2,000 tons per week for the company's own consumption. These furnaces, however, were pulled down in 1899, after a great fire in the works, and on the site of them has been built a large store in order to give more working space to the ordnance department, the former stores in which are now used as gun shops. The company are not now smelting iron, but propose erecting new and improved furnaces at the extension works which are being laid out at Scotswood, about a mile higher up the river. The Scotswood extensions will cover 30 acres and have a deep-river frontage and direct railway connection. Meanwhile, large stocks of pig iron are kept at Elswick ready for the insatiable steel furnaces, of which there are now eight of large size, the charges ranging from 15 to 40 tons per furnace. These steel works, which are about a quarter of a mile long and cover an area of 10 or 12 acres, were originally planned by the late Colonel Dyer, and were for a long time managed by him until he went to take charge of the company's works acquired from the Whitworth company, at Openshaw, Manchester. These works, being on sloping ground, are laid out in terraces—an arrangement which makes the regenerating chambers and valves more readily accessible. The character of the site involved great expense in construction, but the extra cost has, it is estimated, been more than compensated by the greater economy in working from level to level. Thus the upper terrace, just under the railway, receives the raw material, which is run along tracks carried on girders nine feet above the charging floor of the furnaces. The furnaces are on the second terrace, which is the melting floor, and there some 1,200 to 1,500 tons of ingot steel per week are turned out. There also are the circular gas producers for distilling from "duff" coal all the gas required for consumption in the steel furnaces; all the branches are connected by railway with one another, with the other parts of the works, or with the main railway.



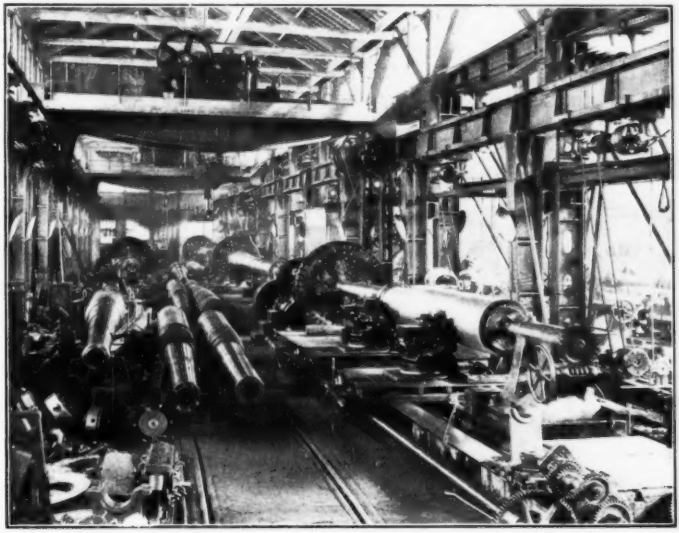
NO. 6 SHOP. TURNING, BORING, AND RIFLING TUBES FOR LARGE GUNS.

On the third terrace is the forging shop, divided into three bays containing respectively the gas producers and reheating furnaces (fed by means of an overhead railway from the upper terrace), the forging press and cranes, and the large lathes and other machine tools for finishing. Between the second and third terraces is a retaining wall on which is carried a railway to serve the foundry and forging levels; and between the buttresses of this railway wall the spaces are filled with reserve supplies of coal. On the fourth terrace are the engines and boilers for driving the forging plant. The engines and pumps are interchangeable, so that, whilst each forging press has its own set, it can, in case of breakdown, be worked by any one of the others. The output of steel is about 50,000 tons per annum, and Elswick is in this comfortable position as regards its steel plant, that any ingots which do not come up to the standard necessary for ordnance can be at once absorbed in other departments of the works in uses for which their physical and chemical character may suit them.

In the steel works are many most interesting contrivances for saving labour and for handling heavy masses. The powerful travelling cranes are a special feature, and these were all made in the Elswick works and are operated by hydraulic power. By these, great masses of glowing steel from the furnaces are turned and manipulated as quick as thought at the touch of a lever by the forgeman. In the forging shop has been turned all the famous propeller shafting that Elswick has supplied to a perfect fleet of British and foreign war-ships. Single ingots have been cast weighing 85 tons, and propeller shafts have been forged upwards of 80 feet in length. To handle such masses very powerful and very perfect machinery is required. Here, for instance, are four great hydraulic presses exerting a pressure up to 5,000 tons. The pressure is supplied by five pairs of Corliss pumping engines, each of 1,000 horse power. There is a special foundry for castings for gun-carriages, marine works, stem and stern posts, rudder frames, and the like. The machine tools for turning and boring forgings and for cutting bolts, ingots, etc., are among the most powerful and delicate in the world. Quite recently two large presses of exceptional power have been added. And here it may be incidentally mentioned that a 12,000-ton press (one of the most powerful constructed) has recently been added to the company's works at Openshaw, Manchester. It was these last-named works that Colonel Dyer (who had been connected with the ordnance works of Sir Joseph Whitworth & Co. before he went to Elswick, and before the amalgamation of the two companies) was superintending at the time of his

lamented death. Colonel Dyer was President of the Federation of Engineering Employers during the memorable strike of 1897-1898.*

The ordnance department is the greatest feature of the Elswick establishment and the main cause of its greatest development. It was the mountain streams of Yorkshire that gave to young Armstrong the idea of utilising the natural force of water for mechanical purposes in hydraulic machinery. It was the Crimean war and the incidents in connection with artillery therein that gave him the idea which found expression in the rifled, coil-built, and breech-loading weapon known as the "Armstrong gun."



NORTH BAY, NO. 11 SHOP, ELSWICK. TURNING MEDIUM-SIZED GUNS.

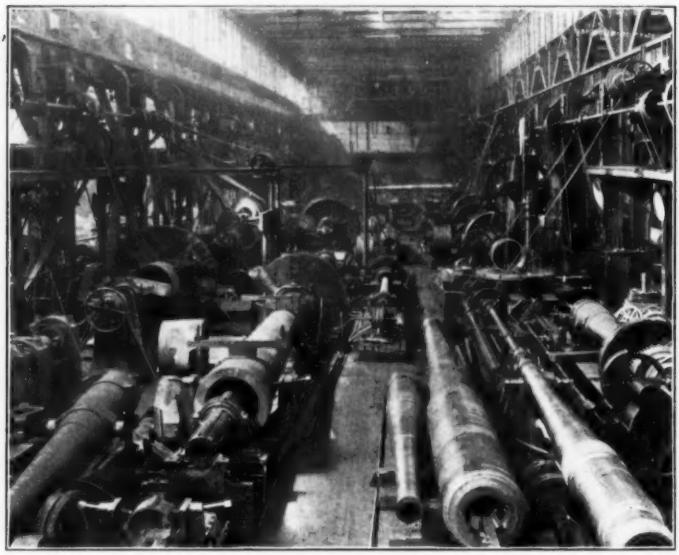
Shows the ample provision of travelling cranes serving the shop floor.

He began to make these guns at Elswick two years before they were adopted by the British Government in 1859, and then, having inaugurated a revolution in ordnance, for two or three years he superintended the Government gun factories at Woolwich, while these factories were being reorganised for the manufacture of the new style of gun. Thereafter the Elswick concern entered into an arrangement to

* The Openshaw works do not come within the purview of the present article. They are, however, a very important part of the Armstrong-Whitworth enterprise. Very great extensions have been and are being made to them, including a department for the manufacture of armour plates for the war-ships built at the Elswick ship-yard.

manufacture for the War Office; Mr. Armstrong was knighted for his great invention, and he associated with himself, as director of the ordnance department of the Elswick works, Captain (now Sir Andrew) Noble, R. A., formerly gunnery instructor at Woolwich and later renowned for his researches into the composition and properties of various explosives.

The ordnance department over which Sir Andrew Noble still presides is a vastly different place from the gun factory which Capt. Noble went to take charge of forty years ago. It covers over 40 acres and gives employment to some 14,000 men, working night and day in peaceful industry for the pursuit of war. It is indeed a town in itself, with more than the population of many an American "city." It is impossible to enumerate all the spacious shops and sheds stacked with giant masses of steel, throbbing with Titanic machinery, and stored



MIDDLE BAY OF NO. 11 SHOP. CUTTING RIFLING GROOVES AND BREECH-PLUG SCREWS IN HEAVY GUNS.

with huge guns of varying greatness in various stages of construction. Here one sees constructive ingenuity of the keenest type employed in evolving destructive machinery of the most deadly character. Here the moralist may find inexhaustible food for thought (if, indeed, he can collect his thoughts at all in the whirr and tangle of some of the

most beautiful and complicated machinery ever devised by human skill) in this seething hive of life whose mission is the pursuit of death. But for the mechanician, the economist—even for the Morleyan "plain man"—a walk through these wonderful shops is a liberal education in itself.

Putting aside the object of the article manufactured, we find at every turn the highest examples of applied mechanics and scientific insight. It is not the purpose of this paper to describe the process of gun-making, but only to give a general sketch of one of the most remarkable evolutions of inventive genius and administrative efficiency that the world has ever seen. It would need a volume to describe the manifold operations in casting, forging, boring, rifling, wire-winding, chambering, and otherwise perfecting, from a raw-steel ingot, the latest pattern of Elswick gun and its complete equipment of hydraulic machinery for mounting and service. The principle now adopted of building up the gun by winding and welding ribbons of steel around the cylinder requires the employment of tremendous lathe-power, and the enormous masses to be moved about the workshop in the various processes of machining require the employment of powerful cranes capable of lifting and travelling with a weight of 100 tons.

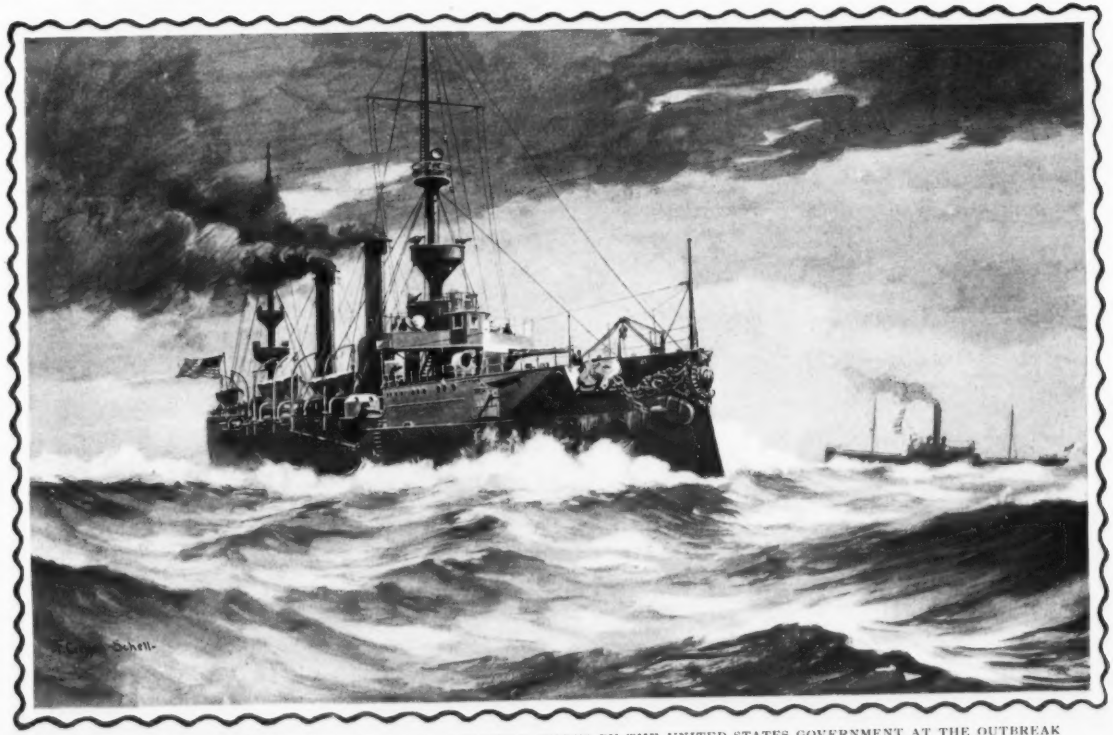
The original "Armstrong gun," the first design of which Mr. Armstrong submitted to the War Office in 1854, has long been obsolete; but in the place of its birth we find the development of the principle it embodied, in the famous 4.7-inch and shapely 12-pounder quick-firing guns which may be said to represent the two highest types of present-day ordnance. But, of course, the 4.7-inch is not the largest gun made at Elswick by any means. The 8-inch is a quick-firer also, throwing four rounds of projectiles weighing 230 pounds each in 65 seconds. It has, however, found more favour in foreign navies than in the British service, in which a 9.2-inch gun has been preferred, while for British battle-ships, wire or ribbon guns of 12-inch calibre are now being forged. One brief comparison will illustrate the development of the last half century. The 6.3-inch 32-pounder of 1850 had a velocity of 1,600 feet per second and an energy of 570 foot-tons. The 6-inch quick-firing gun of 1900 has a velocity of 2,570 feet per second and an energy of 4,580 foot-tons, besides infinitely more rapidity of fire and accuracy. Perhaps the most interesting portion of the whole process of gun-making is the rifling, and it is just here that the most delicate manipulation and most perfect machine tools are required. The process occupies from a week to a month, according to the size of the gun, and at any moment during the

process the slightest deviation of the cutter from its true course may render useless many thousands of pounds' worth of material and labour.

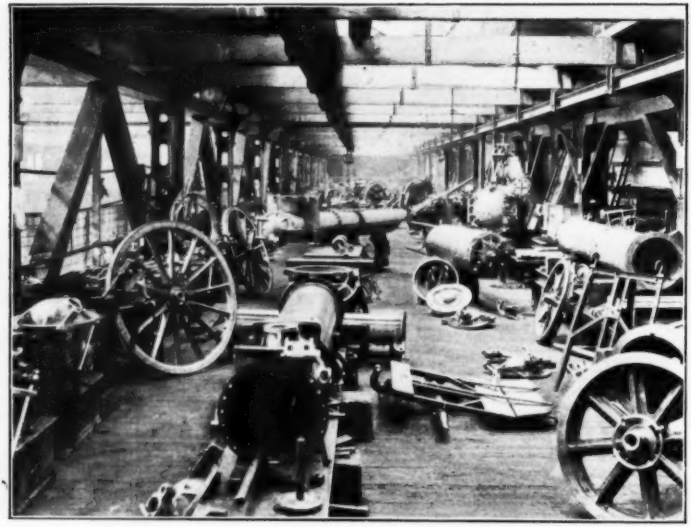
The Elswick ordnance works turn out about 6,500 tons of guns and mountings per annum, though a 10-inch gun takes a year to make, and a 110-ton gun about 18 months. In these workshops are more than four thousand machines of all sorts. The big guns, when finished, are tested on a moor to the west of Newcastle possessed by the company, and then sent for a course of experimental firing at a tidal range at Silloth.

The Armstrong company first became ship-builders in 1882, when they amalgamated with Messrs. Charles Mitchell & Company, at whose yard at Walker-on-Tyne had previously been built the numerous war-ships whose armaments were provided at Elswick. This amalgamation was a good stroke of business for the Elswick company, and the old-established and highly-equipped Walker yard is now, I believe, utilised for the building of merchant craft only, up to the highest type. The removal of the old low-level bridge between Newcastle and Gateshead, the construction of the swing-bridge already referred to, and the deepening of the Tyne above-bridge with the removal of the King's Meadow Island, enabled the company to begin ship-building at Elswick. At the east end of the establishment there were laid down berths primarily designed for the construction of war-ships. This department was for a time under the charge of Sir William White, who on being appointed Director of Naval Construction for the British Admiralty was succeeded by Colonel Philip Watts, under whose able management the Elswick war-ships have acquired world-wide fame. The many wonderful cruisers now afloat under various foreign flags that are peculiarly associated with Elswick, as well as the great Japanese battleship Yashima, are from the designs of Colonel Watts. And to Colonel Watts the writer has to express his grateful acknowledgement for kind assistance in the preparation of this article.

The first thing that impresses a visitor to the Elswick ship-yard is the stupendous character of the work in progress; the next is the admirable manner in which the area is appropriated, not an inch of space being wasted and all the sections being arranged for the minimisation of labour. The yard covers some 16 acres and has a river frontage of 2,000 feet, with ample depth of water at high tide for the biggest ironclad. It was a difficult site to utilise owing to "the lay of the land," but difficulties do not exist long at Elswick. The piling of the berths set apart for the building of heavy war-ships was necessa-



U. S. S. ALBANY. BOUGHT COMPLETE FROM THE ELSWICK WORKS BY THE UNITED STATES GOVERNMENT AT THE OUTBREAK OF THE SPANISH-AMERICAN WAR.

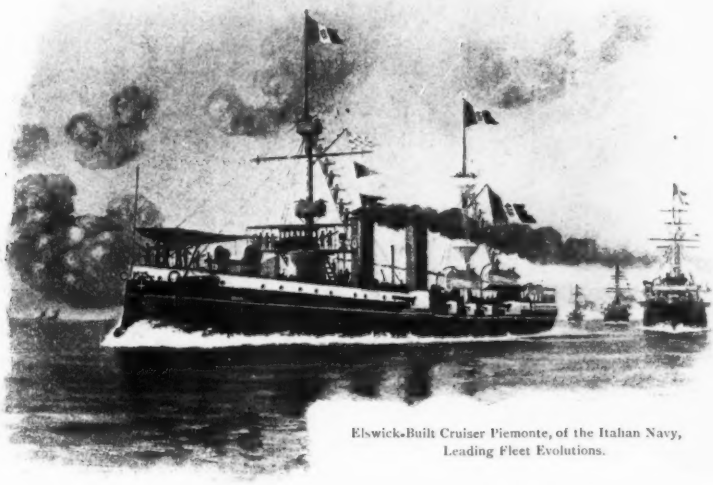


NO. 16 SHOP, ELSWICK. ASSEMBLING RAPID-FIRE GUNS AND TORPEDO TUBES.

rily very costly, but consider what magnificent monsters have been evolved there! The first war-ships built at Elswick were, I believe, for the Austrian navy, but since then almost every navy in the world has been recruited there, sometimes to the specifications of the buyers, but more often to the design of Colonel Watts himself. Among them have been the famous Chilian armoured cruisers O'Higgins and Esmeralda, the Italian cruiser Piemonte, the Argentine cruiser Buenos Aires, and the Japanese cruisers Naniwa, Asama and Tokiwa. But space is not available even to enumerate the many war-ships built, fitted, and armoured at Elswick, much less to describe their special characteristics and the remarkable evolution in war-ship design. The work of building and fitting out war-ships is here carried on in every detail, from the drawing of the plans and laying down the moulds in the drafting loft to the completion of the armament. Great cranes carry and dispose enormous armour plates as easily as if they were feathers, and when the ship leaves the slip, she is ready to be hauled along to the other departments to receive her machinery and ordnance. One shop is devoted to the manufacture of dynamos and electric-lighting apparatus. In brief, it may be said that the characteristics of the war-ships now turned out at Elswick are high speed combined with efficient protection and the most powerful armament. In

point of equipment the ship-yard is one of the finest in the world. At a recent meeting of the Institution of Naval Architects Sir Edward Reed said: "No doubt the exceptional and paramount position of the Elswick works is due to the circumstance that it has been constantly progressing in connection with ships and guns and gun-mountings."

The note of the establishment is in fact, Progress, and its effort not merely to keep abreast but ahead of the times. Thus it occupies a unique position in the world—a complete arsenal in itself, initiated and conducted by private enterprise alone. We say a complete arsenal, for here a war-ship can be designed, built, armoured, fitted with engine and boiler, furnished and equipped with guns, ready to proceed straight out to sea and engage with an enemy in the offing, if need be. Of no other arsenal in the world can this be said.

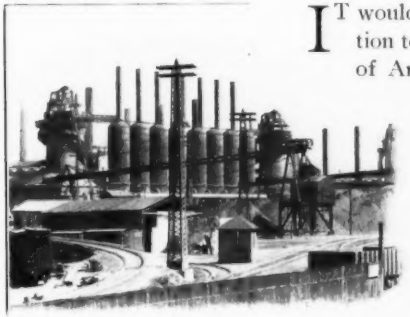


Elswick-Built Cruiser Piemonte, of the Italian Navy, Leading Fleet Evolutions.

ANDREW CARNEGIE.

THE HUGE ENTERPRISES BUILT UP BY ANDREW CARNEGIE.

By Charles M. Schwab.



IT would seem a work of supererogation to present, in a succinct sketch of Andrew Carnegie such as this aims to be, the chronology of his life at length; for many biographers have made familiar the very interesting story of his notable career, from his humble origin through three-score and five years, showing the subject in his successive stations as the bobbin boy, telegraph messenger, telegraph operator, railway superintendent, manufacturer, and philanthropist.

Much less relevant would be the rehearsal of all the many striking incidents of Mr. Carnegie's life, particularly during his boyhood struggles, in a retrospective survey of the quarter century of his life during which he has been *facile princeps* in the development of the American iron and steel industry and in placing the United States foremost of all the nations in that important branch of manufacturing.

Mr. Carnegie's advent into the field of metallurgy followed his retirement from the office of superintendent of the Pittsburg division of the Pennsylvania Railroad. That was just thirty-six years ago, when, it may be said, he was a young man, albeit he will doubtless resent the imputation that he is not still in the heyday of youth. The office of superintendent of the Pittsburg division was not, during Mr. Carnegie's incumbency, the sort of fat satrapy it is to-day, and his emoluments were beggarly ($1,750 per annum) compared with

The influence and the service of Mr. Carnegie's stupendous work as an iron-master can not be defined by any national measure. Steel is the prime necessity of all mechanical manufacture and of practically all constructive work. It is the foundation of engineering expansion and of industrial growth. The man who makes steel cheap and abundant ministers to the whole of material civilisation, and the benefits he brings go hand-in-hand with his product through the world's work-shops. The Carnegie plant is not only an example of management on a Titanic scale: it is the foster-father of a vast company of metal-working establishments within whose reach it has put the substantial element of industrial prosperity —cheap raw materials.—THE EDITORS.

those of "R. P.," as my distinguished friend, Mr. Robert Pitcairn, the present Pittsburg head of the Pennsylvania, is popularly apostrophized. Mr. Carnegie had, moreover, invested the little he had in Adams Express Company's stock and a share in the famous Storey oil farm, so that when the Cyclops Iron Works, the primordial Carnegie enterprise, was decided upon, the founder, reluctant to disturb these small investments, was obliged to borrow his share ($1,250) of the funds needed to finance the undertaking.

The Cyclops company was formed October 14, 1864, to establish an iron rolling mill to supply material to the Keystone Bridge Company, which was organized six months later. Mr. Carnegie resolved upon these ventures while in the service of the Pennsylvania, as a result of successful experiments the railroad company had made with an iron bridge. He foresaw the great possibilities for the iron trade in this direction, and with the self-reliant initiative whch has ever characterized his life set about to establish himself with others in the business. The organization of the bridge company marked an important epoch in the railroad development of the country and the progress of the iron trade. It was precursory to the general substitution of metal for wood and masonry in railway-bridge construction and to the opening of a new and prolific realm to the nascent iron industry.

Associated with Mr. Carnegie in the foundation of the Cyclops plant, which, as its name imported, was really a prodigious enterprise for those uncertain days of civil strife, were Aaron G. Shiffler, J. L. Piper, Thomas N. Miller, Thomas Pyeatte, and John G. Matthews. The Keystone company included Aaron G. Shiffler, John L. Piper, Walter Katte, and James Stewart. About the same time the Union Mills, built in 1861-2 by Kloman & Phipps, were acquired by a company including Andrew Carnegie, Thomas N. Carnegie, Henry Phipps, Jr., Andrew Kloman, Gustavus Praetsch, J. L. Piper, Aaron G. Shiffler and Thomas N. Miller. Of these pioneers Mr. Phipps alone remains to share with Mr. Carnegie the fruits of the sapling which they planted nearly four decades since. The growth of that sapling has been phenomenal and incessant, being comparable now only with the gigantic redwood of the California coast ranges, a marvel of size and strength. More fitting names than Cyclops, Keystone, and Union could not have been given to the enterprises upon and around which the various concerns comprising The Carnegie Company of to-day were reared.

The Keystone company built the first 300-foot span metal bridge over the Ohio and has since erected many of the largest steel struc-

tures throughout the country. The business expanded rapidly during the boom in railroad building after the American civil war and received a great impetus when steel was adopted for building purposes. Soon after these works began operation, it became necessary to provide an independent source of pig-iron supply, and the Lucy Furnace Company was formed and built a small stack which was blown in May 11, 1872.

The manufacture of steel by the Bessemer process was taken up in 1874, the Edgar Thomson Steel Company, Limited, being organized by Mr. Carnegie and others for that purpose. This company was capitalized at $1,000,000 and built a plant for rolling rails, consisting of a Bessemer converter and a rail mill. The American steel-rail industry was then about seven years old, and, under the Morrill and supplemental protective tariffs had attained considerable proportions, although imports continued from England. The Illinois, Pennsylvania, Cambria, and Bethlehem companies had entered the trade in the order named between '65 and '73, but it was not until 1867 that home-made Bessemer-steel rails were laid for the first time in place of iron rails. The prices ranged from $174 per ton in March, 1868, down to $95 per ton in January, 1872. In 1870, when it was proposed to place a duty of $28 per ton on foreign rails, the Hon, S. S. Marshall, a prominent member of the House, made a strenuous protest, declaring that the duty would make the cost prohibitive. On the contrary, prices declined, but not for English rails. Four years after the duty was imposed, American rails sold at $94.25 per ton, and a year later, when the Edgar Thomson plant was put in operation, a marked decline resulted, the average for the year being $68.75 per ton. Rates were scaled down steadily thereafter as the manufacturers improved their facilities and reduced the cost, until the ephemeral boom between September, 1879, and February, 1880, when rails advanced from $50 to $85 per ton, the average for the two years, however, being about $57. Since that time prices have declined steadily, the average for the last twenty years being about $33, and since 1890, $26 per ton.

From a production of 259,699 tons in 1875, when the Edgar Thomson plant started, the American mills reached an output of 2,270,000 tons in 1899. Great Britain rolled only 838,148 tons of rails that year, and not since 1879 has that country equalled the rail output of the United States. The Edgar Thomson works began with a production of about 50,000 tons for the first year and now has a capacity of 650,000 tons per annum. Three blast furnaces were added to the Edgar Thomson plant in 1880 and six others have been built since.

DUQUESNE FURNACES AND STEEL WORKS, DUQUESNE, PA.

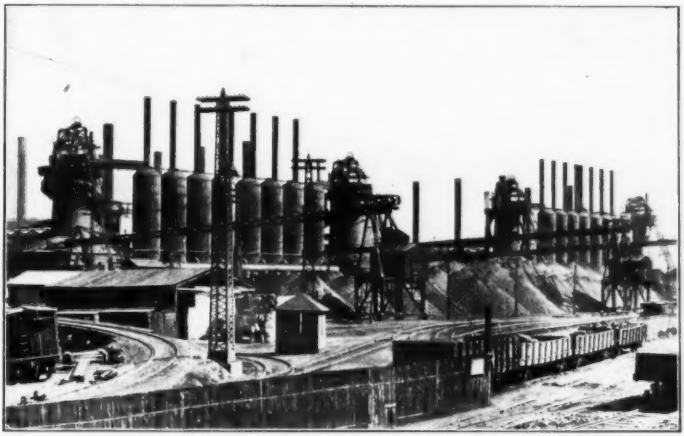
HOMESTEAD STEEL WORKS, MUNHALL, PA.

EDGAR THOMSON FURNACES AND STEEL WORKS, BESSEMER, PA.

THE GREAT CARNEGIE ESTABLISHMENTS.

This somewhat discursive bit of history is interesting in this connection as showing the growth of the most important branch of the American steel industry, in which Mr. Carnegie and the Edgar Thomson works have been the leading factors. For many years after the introduction of the Bessemer process in the United States (1864), the product was used in the manufacture of T rails almost exclusively, but gradually it supplanted puddled iron for structural purposes and the manufacture of rods, nails (1883), and other finished forms. The increased demand for Bessemer steel arising from this evolution was met, or in many cases anticipated, by Mr. Carnegie and his associates, and from time to time the works were enlarged or other steel plants and rolling mills purchased.

The Homestead steel works, built in 1880-1 by the Pittsburg Bessemer Steel Company, and the Duquesne steel works, built in 1886-8, were thus acquired. Both plants had small Bessemer converters and rail trains originally, but the rolling of rails at Homestead was discon-



DUQUESNE BLAST FURNACES, CARNEGIE STEEL CO.

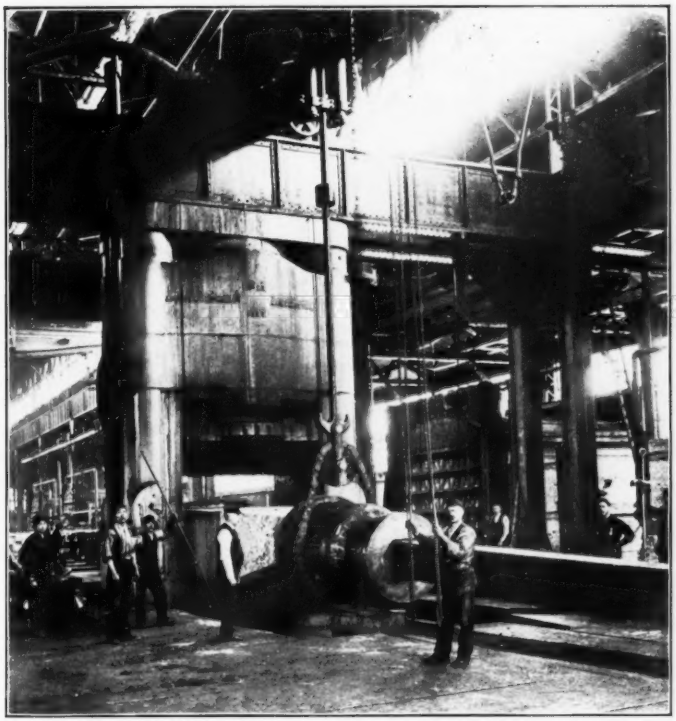
The four stacks have an aggregate capacity of 800,000 tons of iron per annum.

tinued in a short time, and at different periods subsequently other lines were taken up, including the open-hearth steel-making process, the rolling of steel structural shapes, ship and tank plate, and the forging of war-ship armor. The Duquesne plant has also been enlarged, and now includes four of the largest blast furnaces in operation, while an extensive plant for making open-hearth steel is under construction, in addition to several rolling mills.

The growth of the Homestead works has probably been more rapid than any like establishment in the world, and may be ascribed largely to the extended use in recent years of basic open-hearth steel. The first open-hearth plant, built at Homestead in 1886, comprised a small number of basic and acid furnaces. The acid process was after a thorough trial discarded entirely, and additional basic furnaces were constructed. The open-hearth-steel production of the whole United States in 1886 amounted to only 218,973 tons, as against 2,269,190 tons of Bessemer. Last year the Homestead works produced about 1,000,000 tons, or 34 per cent. of the open-hearth output of the United States, which was nearly equal to the total output of the entire country only five years ago.

This remarkable development, it may be observed *obiter,* is a significant sign of the times in the steel industry, denoting, as it does, the increasing preference for open-hearth over Bessemer steel in cases where the use of either is optional. For the last three years the production of Bessemer steel has increased 25 per cent. and of open-hearth 31.5 per cent. The introduction of the pressed-steel freight car partly accounts for this, but the increase of production is due primarily to the improvement in manufacturing practice and in the quality of product. It may be added that the open-hearth process will continue to gain on the Bessemer, and many believe that the latter is going slowly, step by step, the way of the puddling furnace; but the time for numbering its days of usefulness is still remote. However, the additions to productive capacity now building and projected in the United States are in the great majority of cases for open-hearth steel. In England the advance of the open-hearth furnace has been even more marked than in the United States. The change, it may be said, has been accelerated in that country largely by reason of the failing ore supply, with the consequent shortage of Bessemer iron, necessitating recourse to the open-hearth process, which uses scrap iron and steel, the supply of which is comparatively abundant. The Bessemer process lost first place in the British steel industry four years ago, the output last year being only 38 per cent. of the total steel product. Bessemer still holds first place in the United States, the output last year amounting to 72 per cent. of the total, which, however, is a loss of 10 per cent. in six years.

The Carnegie industrial system, which now embraces the mining and transportation of ore by rail and water and the manufacturing of coke, is the growth of years and represents the enterprise of the man who laid the foundation. In this respect it is unlike many contempo-



10,000-TON PRESS FORGING A 90-TON INGOT, HOMESTEAD STEEL WORKS.

raneous organizations recently formed in the steel trade, comprising numerous small concerns originally competitive and created by many individuals.

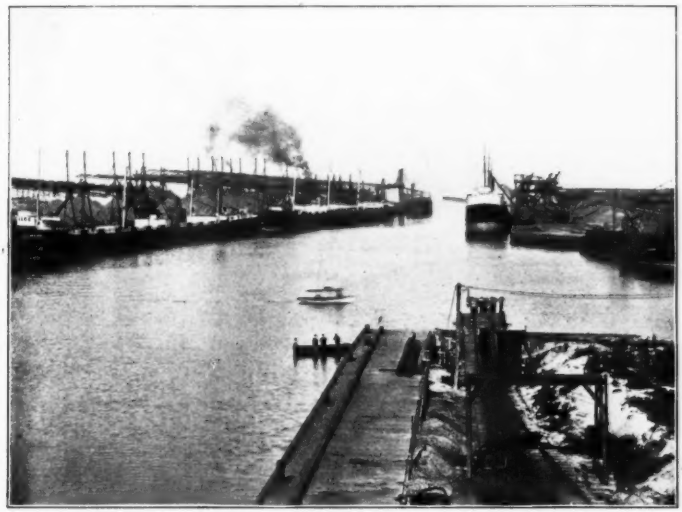
The iron- and steel-manufacturing plants of the company now include 19 blast furnaces (2 building), 3 steel works with 8 Bessemer converters and 56 open-hearth furnaces (12 building), 5 rolling plants with 34 mills, an armor-plate works, and a forge for the manufacture of locomotive and car axles. These are all Cyclops worthy of the Homeric archetype. The works enumerated, with the improvements under way and completed, will have an aggregate capacity of 3,430,000 tons of steel per annum, equal to 32.56 per cent. of the production of the United States, 12.65 per cent. of the output of the world, and nearly 71 per cent. of the production of Great Britain, measured by the production for 1899.

In recent years extensive mines of rich iron ore have been added to the company's possessions in the Lake Superior region, and it now mines about 25 per cent. of the output of the district, which amounted last year to more than 4,000,000 tons. From the docks at the lake shipping ports the ore is carried in vessels owned or chartered by the company to Conneaut harbor, Lake Erie, where it is trans-shipped by rail 153 miles to the furnaces via the Pittsburg, Bessemer & Lake Erie Railroad.

The magnitude of the steel-manufacturing operations of the present day may be appreciated from the fact that during 1899 the receipts of raw material and shipments of finished product of the three largest Carnegie works aggregated 16,000,000 tons, which, according to Mr. J. T. Odell, equalled the combined tonnage handled last year by the Missouri Pacific, Southern Pacific, and Northern Pacific railways, operating 13,000 miles of track, 1,500 locomotives, and 50,000 cars. In the mining, transportation, and manufacturing operations the company provides employment for about 50,000 persons, and disburses yearly about $50,000,000 to its operative and administrative forces. The business transacted is exceeded by few, if any, commercial organizations in America or Europe.

When the reason for the remarkable success of Mr. Carnegie and the business bearing his name is sought, it is easily perceived. Americans, and particularly those within the Pennsylvania coking-coal area and the iron-ore fields of Minnesota and Michigan, need only look around them for the principal cause. Mr. Carnegie simply availed himself of the natural riches indigenous to those favored regions, without which America would not be the leading producer of iron and steel in the world, or Pittsburg the *officina gentium*. As one well-informed writer observed a few years ago, the United States would still be in vassalage to Europe for many iron and steel products but for Lake Superior iron ore and Connellsville coke.

Andrew Carnegie, however, with the prescience which seems to be a common attribute of the Scot, saw or made the opportunities of the early days of the iron industry, grasped them by the forelock, and put his faith and capital into the business with invincible confidence. From the outset he held firmly to the conviction that the United States would in time surpass all other countries in iron and steel making, and he has never hesitated at any risk or sacrifice, however great, which promised to advance the industry. Having assisted in placing America in the lead of all the iron- and steel-manufacturing nations, Mr. Carnegie's single purpose has been to secure the position thus

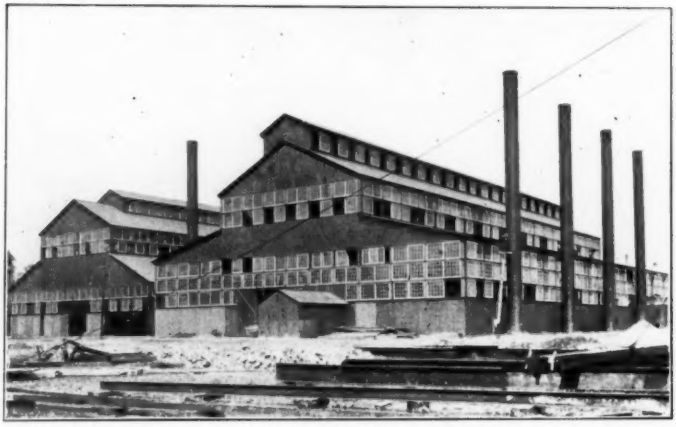


DOCKS OF THE CARNEGIE CO., CONNEAUT HARBOR, OHIO, ON LAKE ERIE, 155 MILES FROM PITTSBURG.

Nine ships can dock at the same time; 25,000 tons of freight can be handled in 10 hours; a 6,000-ton ship can be cleared in 14 hours, and in another 14 hours her cargo can be delivered to the furnaces in Pittsburg; a train of 35-40 ore cars can be loaded in two hours; a 40-ton car of coal can be loaded and partly trimmed in the ship in 36 seconds. On the left are vessels unloading to stock piles; the ship on the right is discharging directly into 50-ton steel cars.

attained by striving unceasingly for the most economical means in the utilization of the country's resources. Starting with the practice which the English preceptors gave with the fundamental iron and steel processes, imposing an everlasting obligation at the same time, America has, thanks to Mr. Carnegie, evolved a system in blast-furnace, Bessemer- and open-hearth-steel making, and rolling mill operations, essentially distinctive from the original, and conceded to be far in advance of the best European methods.

During this transition Mr. Carnegie has frequently been called upon to make large expenditures for new appliances to replace those which had been but recently adopted, and he has done this cheerfully, for with him the best is good enough only until something which promises a better and cheaper product is offered. He has willingly allowed the profits of the business to be taken year after year for experiment and improvement, whilst our friends across the water, content with the crude, anachronic system of by-gone times, took the



EXTERIOR OF HARVEYIZING PLANT AND REAR END OF PRESS SHOP, HOMESTEAD.
This building was completed and running in 8 weeks from the time it was decided to build it. This record is an example of the energy characteristic of the Carnegie policy in carrying out any changes determined upon.

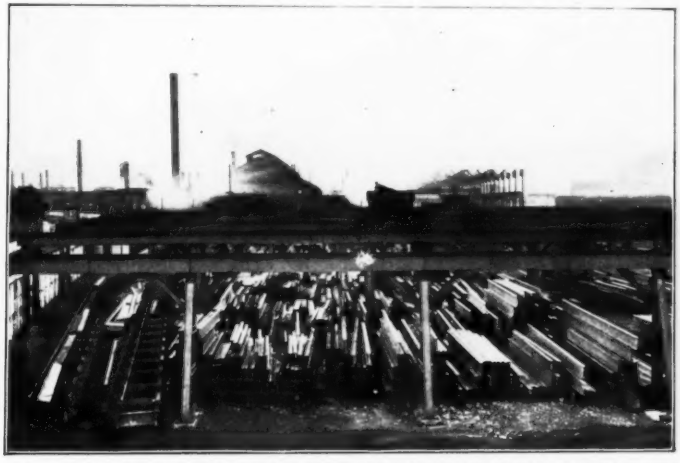
dividends and kept the even tenor of their way. The corollary of this reduced to figures shows that the United States in 1899 produced 39.25 per cent., Germany and Luxembourg 23.20 per cent., Great Britain 18.44 per cent., and the Carnegie works 10 per cent. of the steel output of the whole world, the Carnegie production being equal to more than one-half of the aggregate output of all the works of Great Britain.

For many years the traveller on the Pennsylvania railroad passing Braddock may have observed a broom of immense size towering far above one of the Edgar Thomson furnaces. This broom, as new methods of furnace working were introduced from time to time, was shifted from one stack to another, but it remained always with the Edgar Thomson group, signifying that the furnace over which it was raised had made a clean sweep of the furnace record of the world. The broom finally came down for good, but it was another, or rather several other Carnegie stacks which brought it down when the Duquesne furnaces were put in operation. The breaking of records since has been of such common occurrence that the broom was dispensed with, as the necessity for shifting became too frequent and troublesome.

The capacity of the blast furnace since the first Lucy stack was built in 1872 has been increased from less than 100 to more than 600 tons per day, and two others will shortly be blown in which will produce 700 tons each per day. The development of the blast furnace is

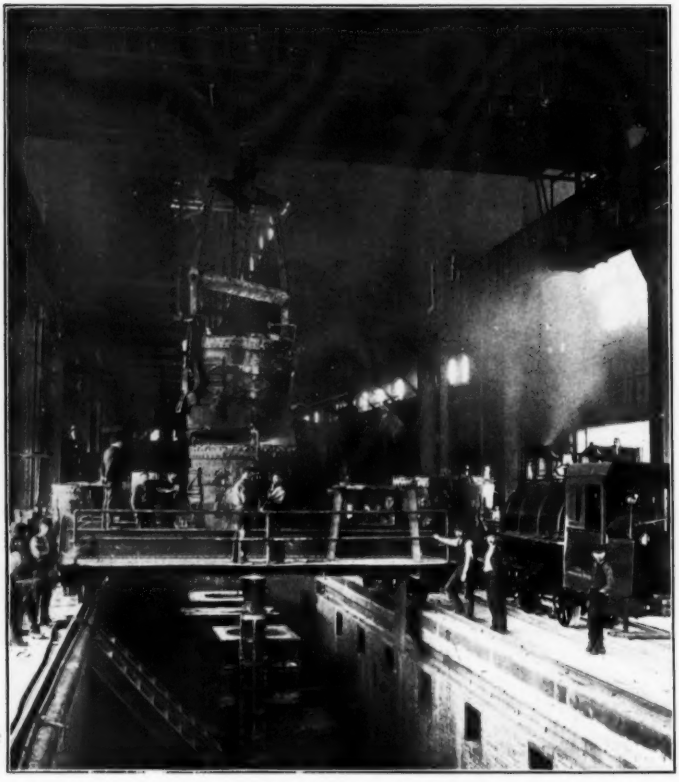
fairly indicative of the progressive march in every branch of iron and steel making as carried on by The Carnegie Company, from the mining of the ore and coal through the entire scale of operations to the final handling of the finished steel. During the 36 years Mr. Carnegie has been identified with the industry, the works under his control have fabricated over 50,000,000 tons of iron and steel for the multifarious uses of civilization, making possible the construction of many miles of railroad that could not have been built had he not been the actuating force in revolutionizing manufacturing and competitive conditions.

Mr. Carnegie has been not only the architect of his own fortune, but has opened the door to opportunity and wealth for many men, sharing his success at all times with his employees and business associates with unexampled liberality. He has made many young employees partners in the business for meritorious service, assigning to them, virtually without the payment of a penny, valuable stock interests, requiring payment only from the profits of the shares, that they might not consider such transfers as gifts but as their due. The first charge on the revenues of the business is for the best-paid labor in the world, and Mr. Carnegie makes it a paramount obligation to maintain that standard and to provide steady employment for the thousands whose welfare is in his keeping.



STORAGE YARDS, HOMESTEAD WORKS, WITH ELECTRICAL APPLIANCES FOR HANDLING BEAMS.

Exemplifying the promptness in applying every agency affording increased convenience or economy in manufacturing operations.



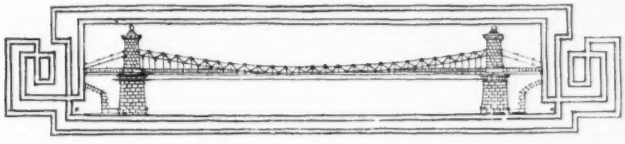
CASTING A 90-TON INGOT. SHOWING THE 150-TON CRANE FOR HANDLING INGOTS AND LADLE, HOMESTEAD STEEL WORKS.

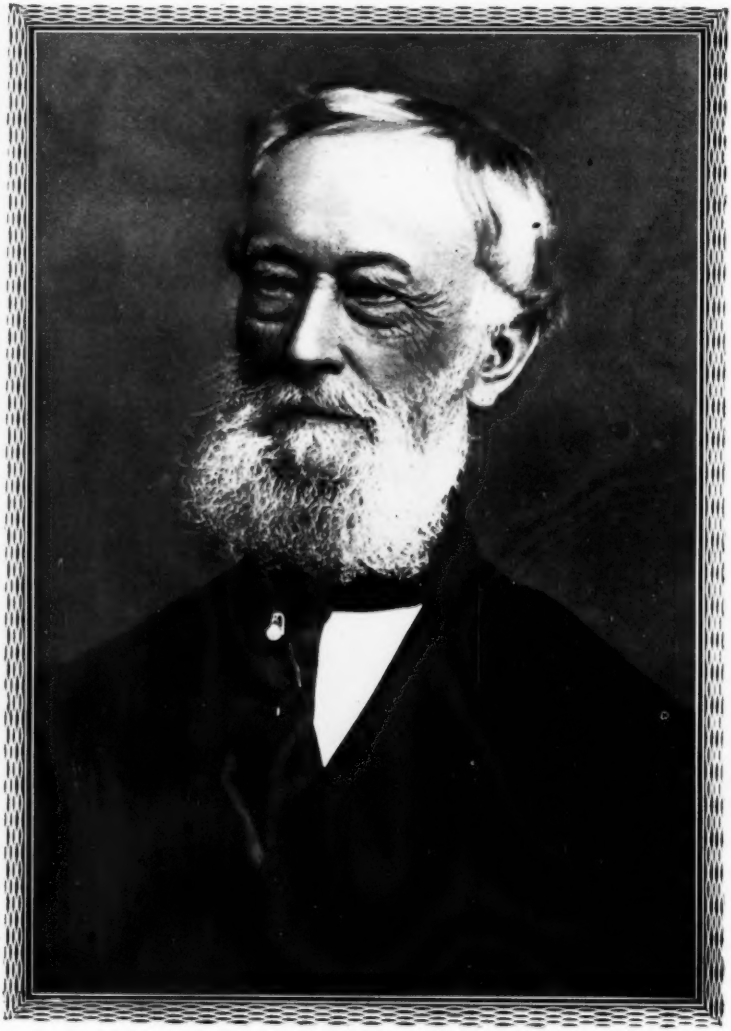
The public philanthropies to which he has devoted millions aim to be practical and are characteristic of their creator, but perhaps the most wisely conceived benefaction of the many he has originated was instituted some years ago for the employees of the steel company. The cardinal canon of his famous "Gospel of Wealth" and the governing motive in all his philanthropic efforts is to help those who try to help themselves. This doctrine was put into practice first when he established a savings and loan fund for the employees, and put a premium on thrift and economy by obligating the company to pay everyone who deposited his savings with the company a higher rate of interest than could be obtained from any public savings institution. The com-

pany has done this ever since, paying a fixed rate of 6 per cent. annually, regardless of business conditions, deficits in interest earnings, or the fluctuation of savings-bank rates, and, in consequence, the fund now has a larger number of depositors with a higher average of deposits than any of the public savings institutions in the mill localities.

For the purpose of enabling the workmen to acquire their own homes, loans are also made from this fund on more liberal terms than can be obtained otherwise, and many of the workmen own comfortable dwellings secured by the assistance thus given. Every department foreman and paymaster in the various works is authorized to receive deposits, and the many chances afforded the workman by this arrangement to put by surplus earnings to his credit with the company before he leaves the works on pay day, have been an effective means of helping him not to squander his money, for the temptations to spend freely and foolishly which beset the average workman before he reaches his family with his earnings are many, and to a large number, irresistible. The company, in addition to guaranteeing the high interest rate, which is about double the amount allowed by banks, assumes responsibility for the entire running expenses of the fund, giving the services of the accountants and clerks needed to transact the business without charge upon the depositors.

While Mr. Carnegie has done much and promises to do more to enrich the race by giving millions to foster what he considers the best adjunct to the public school in the advancement of popular education —the free public library—yet he counts the satisfaction of distributing his wealth as naught compared with the pleasure he has given others in the making of it; for he believes with the philosopher that the highest reward of life's labor is the enjoyment of seeing others benefit by it. That he has been able for so many years to provide the means of livelihood for thousands with good wages and steady employment, helping at the same time to cheapen and extend the use of the principal manufactured product of the country, is to Mr. Carnegie far more reason for gratification than the realization of his best-laid plans for disposing of the income.





ALFRED KRUPP.

Who Chiefly Built up the Vast Krupp Works.

THE FOUNDERS OF THE KRUPP ESTABLISHMENTS.

By E. Schrödter.

OWING to the Thirty Years War and the severe conflict through which Germany passed in the eighteenth and early part of the nineteenth centuries, the fair and powerful empire, in which trade and industry had flourished and great prosperity had reigned, was transformed into a feeble, disunited conglomeration of states, in which habitations were burned down and misery, wretchedness and poverty everywhere prevailed. The iron industry, which, during the middle ages, had reached a state of prosperity in Silesia, in Thuringia, in the Harz, in the Sieg valley and on the Rhine, was also affected by the general depression. In a few spots only were small iron works able to maintain a precarious existence.

Even when, about the beginning of the nineteenth century, the puddling furnace was invented and it had been learned how to use mineral coal in place of the hitherto universally employed charcoal, the financial means were lacking to make use of these new discoveries; and so it happened that while in Great Britain, which was protected by its insular position from the disturbing influences of war, the manufacture of iron received a powerful impetus in the early part of the century, Germany's iron industry was able to take but a very small part in the new developments. It was only about the middle of the century that the real advance in Germany began—slowly at first, but moving with accelerating speed after the establishment of the new empire by Kaiser William I. and Prince Bismarck in 1871. Among the

The Krupp establishments, unlike the other three treated in this group, represent the creative effort of a family rather than that of an individual—the result of persistent purpose and transmitted genius through three generations. Like the Carnegie works, they rose with the tremendous growth of the iron trade; they are associated with the expansion of German military power as Elswick is with the rise of the navy; they parallel the Westinghouse ideals in illustrating the success following the patient, painstaking, thorough development of a mechanical idea, coupled with the commercial ability needed to present it in the market. Like all the huge enterprises whose annals are briefly written here, they display that aspect of genius which has been briefly summed up as "an infinite capacity for hard work."—THE EDITORS.

establishments which, in the course of the century, have developed from small beginnings into great centers of industry, the cast-steel works of Frederick Krupp stands in the front rank.

Frederick Krupp, the grandfather of the present proprietor, descended from a prominent Essen family, established a small forge there in the year 1810. In 1812, the same year in which his son Alfred

KRUPP'S ANCESTRAL HOUSE.

"Fifty years ago, this dwelling, originally a labourer's, was the refuge of my parents. May all our workmen be spared the care and anxiety which the founding of our establishment cost. For twenty-five years the outcome was in doubt, and only after much effort and perseverance have the labours of the past been so wonderfully rewarded.

"May this example encourage others in affliction; may it increase respect for small abodes and sympathy for the great cares so often felt therein. 'The end of labour should be the common weal; then labour brings blessing, then is labour a prayer.' "—*Alfred Krupp, Essen, 1873.*

was born, he offered to the public some cast steel which he had himself made. The manufacture of this material had up to that time been understood only by the English, particularly by Huntsman, of Sheffield, but they were unable to send their product to Germany on account of the closure of the Continental ports by Napoleon's decrees.

With the profits derived from his forge, Frederick Krupp was enabled, in 1818, to build a small plant, consisting of eight melting furnaces, with one crucible apiece, on the spot where the great, world-famed establishment now stands. Although the good quality of his product was recognised, he had not attained complete success at the time of his death in 1826. The cast-steel works were carried on by his

widow and his eldest son, Alfred. The fourteen-year-old boy, who was obliged to leave school, laboured untiringly at the crucibles, assisted by two workmen. While engaged in this hard toil, often lasting through the night, he lived on potatoes, coffee, and bread and butter, without any meat. He was master and apprentice, he was founder and smith, packer and errand-boy, bookkeeper and travelling man. On Sundays he wrote up the books and made out the accounts.

The two workmen were gradually increased to five, and by 1832 there were ten, besides Alfred's younger brothers, who now assisted him. One of the first successes of the young establishment was the preparation of mint dies, and after Krupp had invented a special roll for the manufacture of spoons, orders flowed in so rapidly that in 1842 he was able to employ 100 workmen. In 1843 he forged the first gun-barrels with his own hand, but he did not have success with them. In 1847, the year of famine and political disturbances, the number of workmen fell from 188 to 72, and Krupp hazarded his last penny to continue the payment of wages.

About the middle of the century the railway era began, which made heavy demands upon the iron industry. Krupp took a leading part in supplying this demand, and distinguished himself by the invention of the seamless wheel-tire, which he made by taking a round cast plate, making a conical hole in it, and then driving mandrils of increasing diameter through the opening until the desired size was attained.

At the first international exposition, the London World's Fair, in 1851, Krupp exhibited a cast-steel ingot of 45 hundred-weight and a six-pounder cannon, also of cast steel, for which he received the highest award. At Paris, in 1855, his exhibit contained a cast-steel ingot of 100 hundred-weight and a twelve-pounder. At last he received the first order for artillery from the Prussian government, and the goal toward which he had struggled for many years was reached. Krupp cannon soon had an opportunity to prove their metal in actual warfare, as at the terrific bombardment of Missunde in 1864, and in the battle of Königgrätz in 1866. As a result heavy orders came in, not only from Prussia, but also from Russia, Italy, Turkey, and other states. The establishment was, in consequence, continually enlarged, iron and coal mines were bought, and new inventions were introduced. About this time Krupp left his old dwelling, which stood in the midst of the works, and built a country villa at Bredeney, about three miles away, which in the course of time has developed into a princely residence. The year 1867 brought Krupp new fame through the exhibit of a steel ingot weighing 40,000 kilogrammes (88,000 pounds), and a

giant cannon of 14 inches internal diameter and with a length of 21 feet. In 1868, at a shooting trial at Tegel, he drove the Armstrong cannon from the field. In 1870, 2,000 Krupp cannons forced Sedan to capitulate. At Vienna, in 1873, and at Philadelphia, in 1876, he astonished the world with new and wonderful works. Emperors and kings visited the cannon king, who was loaded with worldly honours.

On July 14, 1887, he departed this life, bequeathing his vast properties to his only son, Frederick Alfred Krupp, who had qualified himself for the succession by toiling early and late in the works. The new proprietor was not only able to fulfil the difficult task of conserving the existing establishment, but he also enlarged the work in all directions and added new branches, so that at present more than twice as many workmen are employed as there were at his succession less than fourteen years ago.

The establishment to-day consists of the cast-steel works at Essen; the Krupp steel works, formerly F. Asthöwer & Co., in Annen, Westphalia, where steel castings of all kinds are the principal product; the Gruson works at Buckau, near Magdeburg, where hardened cast armour, armoured turrets, crushing machines, and so on, are made; four blast-furnace plants, at Rheinhausen, Duisburg, Neuwied and Engers; four coal mines in various parts of the Empire, namely, the Hannover mine, shafts Nos. 1 and 2; the Hannover mine, shafts Nos. 3 and 4; the Sälzer and Neuack mine, and the Hannibal mine; part interests in other coal mines; a great number of iron mines in Germany and several iron mines in Spain; a proving ground at Meppen, 16.8 kilometers (10.5 miles) in length, with provision for extending the firing range to 24 kilometres (15 miles); three ocean steamers; several stone quarries; clay and sand pits, etc., etc. Besides all this, the firm of Fried. Krupp operates, by contract, the Germania Ship- and Engine-Building Company, of Berlin and Kiel. At the latter yard far-reaching enlargements are in progress, as is also the case at the parent works in Essen, where many large new buildings are being erected in order to satisfy the increasing demands made upon the melting furnaces, the armour-plate factory, and the cannon works. The new blast-furnace plant at Rheinhausen, opposite Ruhrort, consists of three furnaces, 23 meters (75 feet) in height, each with a daily capacity of 230 tons. It is purposed to add a basic-steel works to this plant before long, while at Essen only acid converters will be operated. According to figures taken in October, 1900, the above enumerated works employed not less than 46,700 persons, including 3,733 officials.

As sole owner, Herr Krupp has the general management of the

F. A. KRUPP.

The Present Representative of the Family.

gigantic works at Essen and its branches, but he has transferred to a board of twelve directors the most comprehensive powers for conducting the business. The whole establishment is divided into about one hundred departments and offices, each of which is managed by a single head, with the help of assistants. According to their kind, related groups are combined to form sections, at the head of each of which is a responsible chief. The various auxiliary departments, such as the gas- and water-works, the laboratories, and the fire department, to which alone 95 men belong, are under the direct control of this "Direktorium."

The oldest specialty of the cast-steel works is the production of crucible steel; that is, of steel which is made by the melting together of specially-prepared iron and steel in closed crucibles, from which the metal is cast into ingots, the largest of these attaining a weight of 85,000 kilogrammes (187,000 pounds). For casting such an ingot more than 2,000 crucibles are required, and it takes hundreds of foundrymen, working in military order, to collect the molten metal into one mould. The highest quality of raw material is used in the production of crucible steel, and, starting with the ore, all the processes are carried on in the firm's own establishment. This steel is distinguished for the great purity of its material, and the ingots cast from it—even to the heaviest ones—are entirely homogeneous, solid, and uniform—a result which cannot be attained so certainly by any other process.

Crucible steel is therefore employed at the works in the manufacture of all products in which high reliability is of the first importance; it is thus used, above all, for cannon tubes, gun barrels, and armour-piercing shells, as well as for the more important parts of locomotives, stationary engines, marine engines, hoisting engines, and for large rolls for iron plates and armour plates. It is also used for parts in which the least possible amount of abrasion is to be combined with great security against fracture, as in wheel tires and axles of locomotives, tenders, and cars, for tools and springs, for gold and silver rolls, mint rolls, mint dies, etc.

The Martin steel made at the cast-steel works is used, in general, for purposes similar to those for which crucible steel is employed, with the exception of cannon tubes, which are made exclusively of crucible steel. Martin steel is also largely used in ship-building, for plates and angles, for armouring war-vessels, for projectiles, for parts of gun carriages, for boiler plates, for railway-car axles and wheel tires, for springs, wire, and so on.

The manufacture of steel castings out of crucible and Martin steel

is carried on very extensively at Essen. Castings are made for railway material, such as points and switches, for wheels for locomotives and cars—the manufacture of cast wheel centers and web-wheels being a specialty of the works—for machine parts, for parts of ships, such as stems and stern-posts, rudders and screw-propellers, for construction work, and for various other purposes. The castings are made of the most complicated forms and in weights running up to more than 60 tons, this being another specialty of the Essen establishment.

A particular branch of manufacture is the production of puddled steel. The greater part of this is used at the works as raw material for crucible steel, but it is also shipped outside for special purposes, such as the manufacture of wheel tires for artillery carriages in heavy service, and it has a large sale, under the name of "milano" or "bamboo-steel," in transmarine countries, where it is used for tools.

CASTING CRUCIBLE STEEL AT THE KRUPP WORKS.

The Bessemer steel produced at the cast-steel works is used principally on the permanent way of railroads for rails, fish-plates, base-plates, and so on.

Besides the kinds of steel already mentioned, there are prepared various alloys of steel with tungsten, nickel, chromium, molybdenum, etc., which are used for special purposes.

The Krupp firm has gained its universal reputation by the manufacture of cast-steel cannon, of which there had been delivered not less than 38,478 pieces up to the end of 1899. These comprise ship's guns and coast-defence cannon, with calibres from 3.7 to 42 centimeters (1.45 to 17.5 inches), siege guns, cannon for fortifications, field and mountain artillery—including rapid-fire field and mountain guns—all in complete batteries, with equipment and ammunition, ammunition carts and supply waggons, and army vehicles for every purpose.

The Krupp firm has made the double-wedge breech block, which was introduced in Prussia in 1861, a particular factor in the development of its business. In 1865, Krupp introduced the single wedge, with semi-cylindrical rear surface, called round wedge for short, which is the fundamental form of all Krupp wedge breech-blocks. Compared with the screw breech-block, the wedge block has certain advantages and disadvantages, but the experience of the firm seems to show that the former preponderate. This opinion may be strengthened by the circumstance that France, the home of the screw block, in selecting a new rapid-fire field gun, has chosen not the screw block, but, according to all appearances, the Nordenfelt breech mechanism with eccentric screw, which is a breech-block whose mode of operation is essentially that of the wedge block.

Hand-in-hand with the making of cannon goes the manufacture of steel armour, "semi-armour," percussion shells, armour-piercing shells, steel bomb-shells, steel shrapnel, cast-iron shells with fuses, cartridges, fuses and fuse mechanisms, and gun barrels.

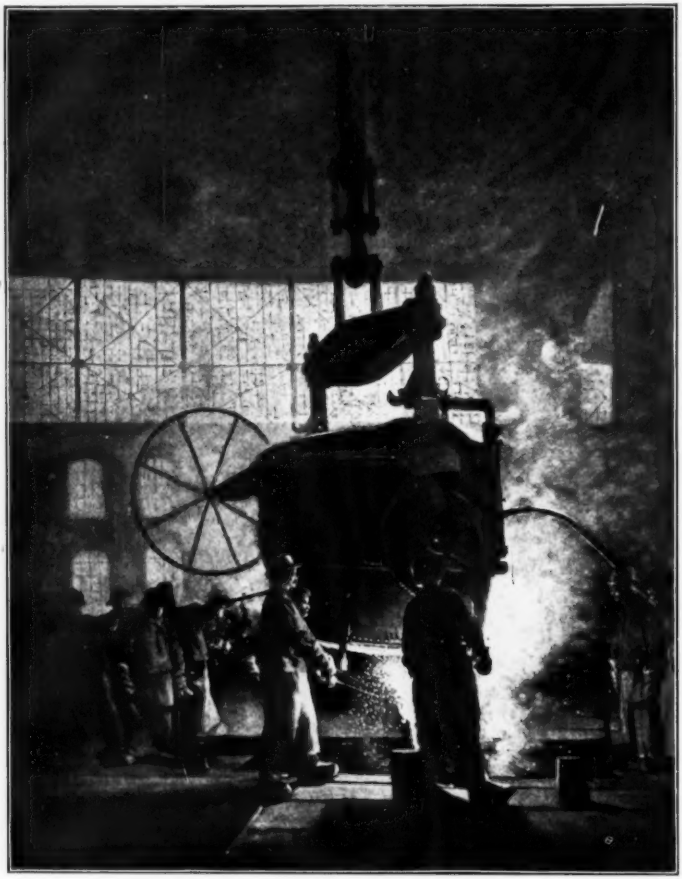
For the manufacture of armour plate there is a great rolling mill and a 5,000-ton hydraulic press. Armour-plate manufacture has gone through five stages. The first plates were made of wrought iron. In 1873, C. Cammell & Co. invented the compound plate, which was prepared by pouring liquid steel onto hot iron plates. Then Schneider, of Creusot, demonstrated that steel plates were preferable. These were further improved by alloying the steel with nickel; and, more recently, by the process, invented by the American, Harvey, of face-hardening the plates by causing the outer layers of metal to take up a greater percentage of carbon. As is well known, the Krupp firm has discovered a new process, that is kept secret, for hardening steel plates as well as nickel-steel plates, by which a product of unexcelled quality is turned out. The principal armour-plate makers of America, England, and France are now using this process, under agreement with Krupp.

At the beginning of 1900, the real estate belonging to the Krupp firm in Essen and the surrounding communities, not including the dis-

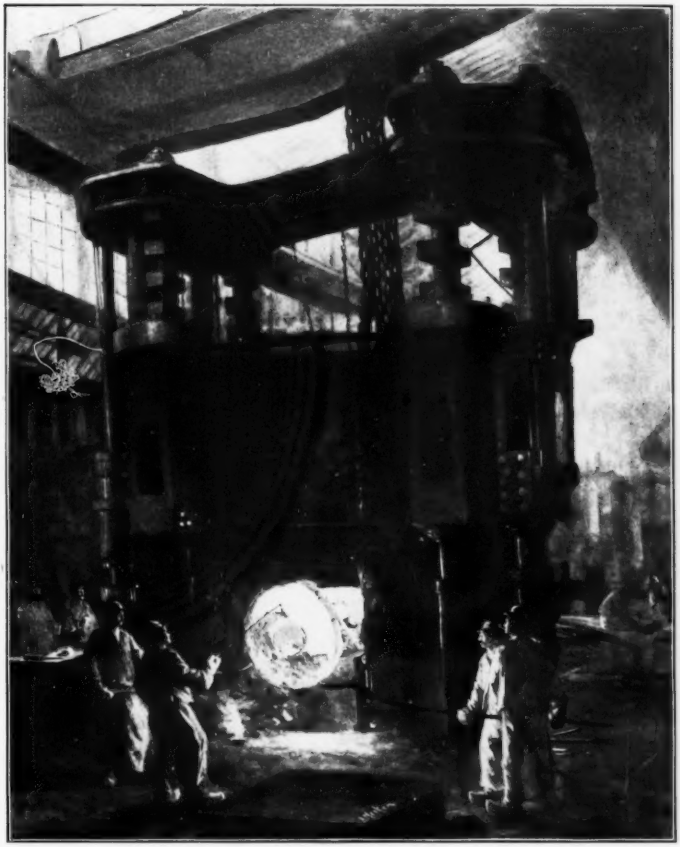
trict of Hügel, amounted to about 360 hectares (890 acres), of which 62 hectares (153 acres), were covered by buildings. At the various Krupp iron mines there has been for the past few years an average daily output of ore amounting to about 1,877 tons. The firm's coal mines have produced about 3,738 tons a day, on an average, but the coal consumption in all branches of the business averaged 5,000 tons a day, or over 1½ million tons per annum. About 115,000 kilogrammes (253,000 pounds) of refractory brick and stone, and from 2,000 to 2,500 melting crucibles are made and used every day. The

KRUPP ARMOUR-PLATE ROLLING MILL.

water consumption of the cast-steel works at Essen alone amounts to over 15 million cubic meters (530 million cubic feet) per annum, or as much as that of a city of 400,000 inhabitants. There are 171.59 kilometers (107 miles) of water pipe underground, and 106.48 kilometers (66 miles) inside the buildings. The annual consumption of illuminating gas is nearly 19 million cubic meters (670 million cubic feet), and the Krupp gas works, according to production, ranks seventh in the German Empire. Electric current is generated in three



CASTING OPEN-HEARTH STEEL AT ESSEN.



THE 5,000-TON HYDRAULIC FORGING PRESS

engine rooms and six distributing stations, and feeds 877 arc lamps, 6,724 incandescent lamps, and 179 motors.

Transportation at the cast-steel works is provided for by a standard-gauge railway system with 58 kilometers (36 miles) of track, 16 locomotives with tenders, and 707 cars, and also by a narrow-gauge system with 44 kilometers (27 miles) of track, 26 locomotives, and 1,209 cars. Cars arrive at and depart from three stations where there are fifty trains daily.

In the testing plant of the cast-steel works at Essen, as well as in those of the plate rolling-mill, the rail mill, and the gun-carriage shop,

there were made altogether in 1899 173,209 resistance tests of materials, of which 87,626 were breaking tests and 83,262 bending tests. In the same year, 26,240 analyses were made in the chemical laboratory of the cast-steel works.

Although the German government provides in a comprehensive way for sick, old, and injured workmen by means of sick funds and old-age and invalid insurance, and the trades associations also help in this benevolent work, yet the Krupp firm has instituted a great number of philanthropic enterprises which go far beyond the boundaries of the legal requirements.

During 1899, the firm paid out 1,103,619 marks ($262,767) on account of the sick-insurance, the mining, the accident-insurance and the old-age and invalid-insurance laws, and 1,095,973 marks ($261,422) in other statutory contributions. Besides this there were a number of extraordinary payments, some of them very considerable, which it is not possible to enumerate in this place.

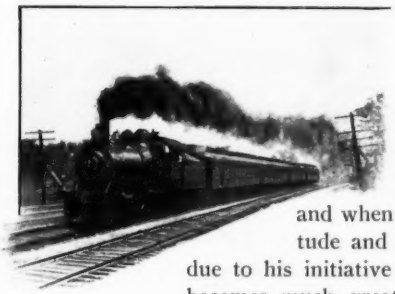
In 1853, Alfred Krupp established a fund for assistance in case of sickness and death, which, after legal provision was made for sick-funds, had its scope enlarged. A pension fund, independent of government requirements, assures to every Krupp workman, in case of disability after 15 or 20 years' service, a retired pay amounting to 40 per cent. of his wages, which percentage is increased after longer service. The pension fund, with assets of 5,000,000 marks, pays out 500,000 marks annually in this manner. A life-insurance society was also founded by Alfred Krupp, with a liberal donation. The Colony of Altenhof is intended exclusively for old and disabled faithful employees.

Up to April 1, 1900, Friedrich Krupp had erected 4,853 family dwellings, in several colonies, to which must be added several hospitals, casinos, libraries, schools, and other buildings. There is also a large store, in which, at 47 counters, provisions and useful articles are sold to employees of the firm at low prices. Besides this, the firm has its own slaughter houses, bakeries, tailor shops, shoe shops, a hotel, and several beer halls and coffee rooms.

One may cast a glance into the modest room of a workman's dwelling, or gaze in wonder at the casting of a mighty ingot of crucible steel; one may spend an hour at the house-keeping school, or follow the flight of a 24-centimeter shell, but everywhere one perceives the touch of a great genius, whose spirit animates this gigantic creation in all its details, holds it together, and enables it to perform works which excite our amazement and admiration.

GEORGE WESTINGHOUSE—INVENTOR, ORGANIZER, AND DIRECTOR

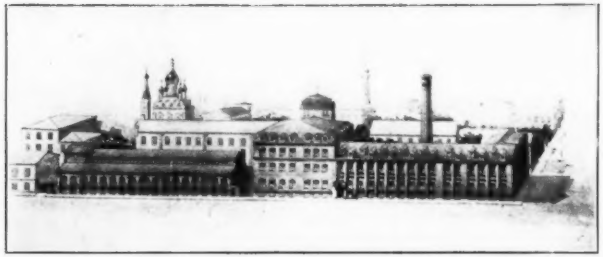
By Walter M. McFarland.

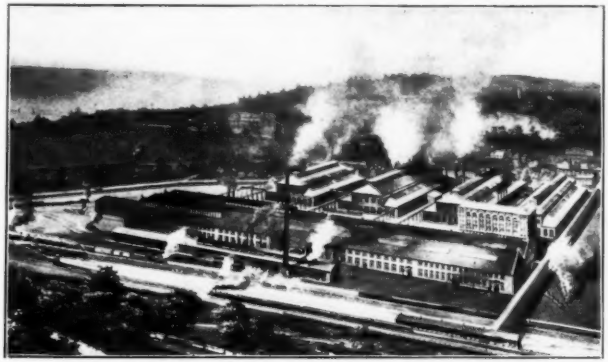


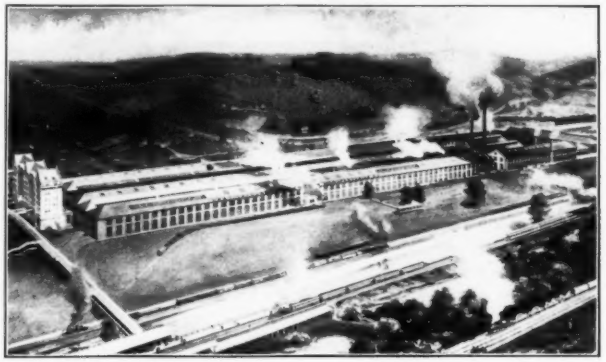
WHEN a number of great manufacturing establishments, covering several important industries, bear the name of one man, there is a natural desire to know something about him; and when it is understood that the magnitude and success of these enterprises are due to his initiative and guiding hand, the interest becomes much greater. There is a feeling on the part of almost everyone that if we could but understand his character and life we might perhaps discover the antecedents to success; and to those who realize that there are younger men coming on who must some day take the place of these leaders, there comes the thought that the life of such a one may be an inspiration and help to some worthy successor. There has probably never been in the history of industry a life which will better repay careful study than that of the subject of this sketch, Mr. George Westinghouse, whose name is undoubtedly as widely-known as that of any engineer or inventor who has ever lived, for his most famous product—the air brake—has gone wherever the advance of civilization has carried the railroad.

It may be well at the start to correct an impression, which seems to prevail to some extent, that Mr. Westinghouse is an old man. This is doubtless due to the fact that the air brake has been widely used for so many years; as a matter of fact, he is still a young man, having been born in 1846. He comes by his engineering ability naturally, as his father was a manufacturer before him, and the old works under the name of "George Westinghouse & Company" are

The genius of George Westinghouse is of the type generally distinguished as characteristically American—the combination of the skill and ingenuity of the inventor with the highest form of managerial and commercial ability. Mr. McFarland shows impressively how large a part in his success has been played by boundless capacity for hard and unremitting work, supplementing the other two great factors—first, the contribution of some great improvement to the economy of engineering, and, second, the faculty of organization in its production. On this triple foundation—inventiveness, organization, energy—the structure of successful manufacturing is securely raised.—THE EDITORS.





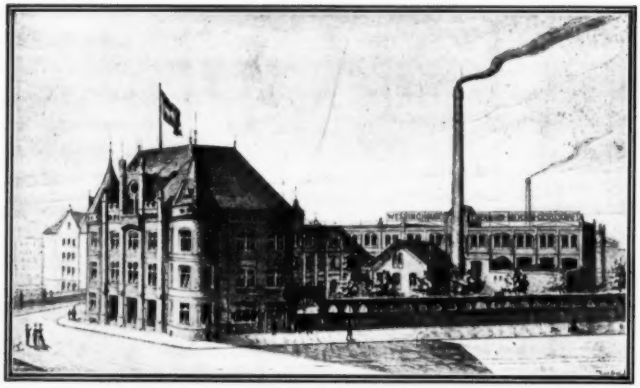


SOME OF THE PRINCIPAL WESTINGHOUSE ESTABLISHMENTS.

Westinghouse Air-Brake Works, Wilmerding, Pa, U. S. A.
Westinghouse Machine Co.'s Works, East Pittsburg, U. S. A.
Westinghouse Air-Brake Works, St. Petersburg, Russia.
Westinghouse Electric & Mfg. Co., East Pittsburg, U. S. A.

still in existence at Schenectady. He displayed a strong mechanical aptitude at an early age, and had become familiar with tools and skilled in their use when the United States civil war broke out. Although still only a boy, he took his part in the struggle to preserve the Union, and served for more than a year in the army, first in the infantry and afterwards in the cavalry. Realizing, however, that his mechanical aptitude would enable him to render more valuable service in the navy, he became an engineer officer and served until shortly after the close of the war, when he resigned. It may be said, in passing, that the engineer corps of the navy has always felt proud that it numbered at one time among its members an engineer of such distinguished ability and one who has done such splendid work.

After leaving the navy Mr. Westinghouse returned to his home in Schenectady, where Union College is located, and for a time was a student in that institution; but feeling the desire for active engineering work, he did not complete the regular college course, but devoted himself to the practice of engineering. He developed a special railroad frog which was a success, and was engaged in its exploitation when his attention was called to the deficiency of the brake apparatus on railroad trains. The invention of the successful brake was an evolution from the crude methods then in vogue, which were, in effect, the application, on a larger scale, of the familiar wagon brake. He soon saw that there must be a motor cylinder under each car, and the natural impulse was to use steam. The difficulty from condensation, however, negatived this method. While studying this problem, his close touch with engineering progress made him aware of the successful transmission of power by means of compressed air in the boring of the Mont Cenis tunnel, and it occurred to him that here was an efficient means of applying power to the motor cylinders of the brakes on railway trains. Mr. Westinghouse is not one of the dreamy inventors of whom the world thinks as waiting for an inspiration to come full-fledged, like Minerva from the head of Jove, but with him to have an idea is to begin to work it up in thorough engineering fashion, with the added ability to make any machine with his own hands. Constant study, experiment, and hard work enabled him to develop the necessary details of the air brake, and then came the question of giving it an actual working trial. In connection with the introduction of the air brake we see some of the characteristics which have contributed to his success, viz., his business acumen and the determination to subject his inventions to an actual working trial before putting them on the market. To make the trials on a large scale meant the ex-



WESTINGHOUSE BRAKE WORKS, HANNOVER, GERMANY

penditure of a large amount of money, and Mr. Westinghouse himself was not possessed of sufficient means at that time. He, therefore, associated with him a capitalist who had the necessary means, and after great effort and much discouragement found a progressive railroad man, who, after studying the brake, had sufficient faith in it to place at his disposal a train upon which to experiment. It is very pleasant to add that this gentleman, upon whom Mr. Westinghouse justly looks as one of his best friends, has been associated with him for many years in the Air-Brake Company. The brake had been worked out so thoroughly that it was a success from the start, and, indeed, on the very first occasion when it was used it resulted in the prevention of a serious accident. From that time its introduction went on rapidly, and it would soon have been difficult to find any road whose passenger trains were not fitted with Westinghouse brakes.

After the successful introduction of the air brake in the United States, Mr. Westinghouse went abroad to secure its introduction in Europe, and here again his mechanical skill, business ability, tact, and attractive personality led to its gradual introduction and the practical supplanting of all other brakes. The case here was not quite the same as it had been in America, for the success in the latter country had led to inventions suggested by his, but on somewhat different lines, in order to evade his patents. These, however, were never the success that the Westinghouse brake was from the start; indeed, the history of the Westinghouse brake and its rivals, as printed in the technical papers, was the best advertising that could have been secured.

While discussing this phase of his activity, and to make it com-

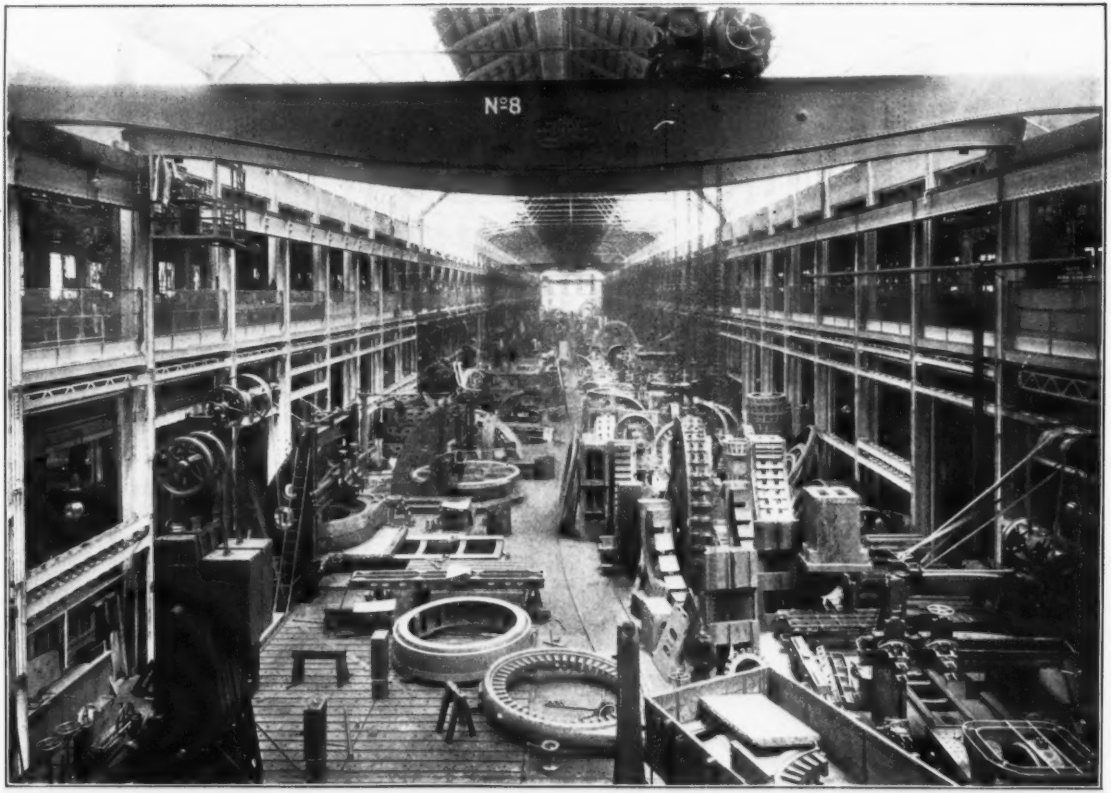
plete, it may be said, as showing other qualities of his character, that he was always seeking to improve the brake, and his invention of what is called the "triple valve" was so great an improvement as almost to equal the invention of the brake itself. As is well known, this enables the brakes to be applied almost instantaneously on a train of as many as sixty cars, and it also led to the great advantage that if a car breaks away from the train the brakes are instantly set—a fact which has prevented many an accident. A mere inventor would have been satisfied with the success and perfection of his mechanism, but Mr. Westinghouse is much more than an inventor; he is a shrewd business man and an organizer of the very first rank. Consequently when the use of the brake had developed, his next care was to organize its manufacture so as to produce the apparatus cheaply and in large quantities. The air-brake works at Wilmerding, Pa., constitute a factory which is probably as nearly perfect as one can be made. A visit to these works is a perfect treat to an engineer, who sees the differentiation and specialization of manufacture combined with the utmost accuracy and highest finish, where these are necessary or desirable, and the whole so arranged that, while the workmen receive high wages, the product is so cheap that it was found by actual trial on the part of one railroad that it was cheaper to buy the brakes from

LATHE DEPARTMENT, WESTINGHOUSE AIR-BRAKE WORKS, WILMERDING, PA, U. S. A.

Wilmerding than to manufacture them upon a very small royalty. In all this development Mr. Westinghouse has taken a most active part, and it is his own work in every respect. When he planned the works at Wilmerding he made them about twice the size that any of his friends and advisers believed to be necessary, but the accuracy of his foresight has been fully justified by events which have shown that he estimated the future demand much more fully than did his contemporaries. This foresight and courage are characteristics of Mr. Westinghouse which impress themselves most strongly upon those who are permitted to know his plans.

It was through his connection with railroading that Mr. Westinghouse became interested in electrical development by way of the pneumatic devices for switching and signaling, which are controlled electrically. Having already made such a successful application of pneumatic transmission of power in the air brake, it was a logical development to use it for operating railroad switches; and in working out the details of the mechanism, Mr. Westinghouse, who was familiar with electrical practice as then developed, found that this agent could be usefully applied. This led to his taking a more active interest in electrical matters, so that he was one of the earliest to see the immense possibilities in the application of electricity for lighting and power.

This led him to acquire the control of some important electrical patents covering the use of alternating currents, and to form the Westinghouse Electric & Manufacturing Co. for the manufacture of electrical machinery, where he surrounded himself with progressive electricians, many of whom are still connected with that company. No one but a man of Mr. Westinghouse's invincible determination, persistence, and courage could ever have developed the use of the alternating current as he has done. It was opposed by the older electrical companies, who did everything in their power to prevent its introduction. The effort was made in some States to get laws passed forbidding its use, and when electrocution was adopted in New York, underhand means were employed to purchase a Westinghouse alternating dynamo, in order to make it appear that the alternating current was intrinsically more dangerous than direct current. In spite of all these obstacles Mr. Westinghouse persevered, and his first great triumph was the lighting of the World's Fair at Chicago in 1893. Here again the wonderful characteristics of the man as inventor, mechanic, and man of affairs were admirably displayed. He took the contract for lighting the fair at a price more than a million dollars less than had been offered by other companies. They, in the effort to crush



MAIN AISLE, WESTINGHOUSE ELECTRIC & MANUFACTURING CO., EAST PITTSBURG, U. S. A., WHERE THE HEAVIEST ELECTRICAL WORK IS BUILT

him, endeavored to persuade the exposition authorities that he could not secure adequate bonds that he would carry the scheme through, and it is an actual fact that he furnished three separate bonds equal to the amount of the contract. After the contract was taken it would have seemed to an ordinary man as though everything was conspiring against him, for injunctions were obtained to prevent his using the Edison patents in the manufacture of the lamps, as well as the air pump for exhausting the bulbs, which was at that time supposed to be the best. Mr. Westinghouse himself invented another form of lamp.

MAIN MACHINE SHOP, WESTINGHOUSE MACHINE COMPANY, EAST PITTSBURG, PA., U. S. A.

known as the "stopper pattern," and not only invented the lamp, but invented and built machines for the accurate grinding of the stoppers and the necks of the bulbs. He also developed a special form of air pump to secure the exhaustion. All the world knows how beautifully and successfully the World's Fair was lighted, and it is a fact that the million-dollar surplus which was distributed to the stockholders is just the amount that Mr. Westinghouse saved these stockholders by taking the contract for the lighting. This was the largest installation of alternating-current apparatus which had been made up to that time, and all who visited the Chicago Fair will remember the section of Machinery Hall which was occupied by the Westinghouse generators. His next great triumph with alternating-current generators was the Niagara installation, which was by far the greatest electrical installa-

LIGHT-WORK DEPARTMENT IN THE WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY'S PLANT, EAST PITTSBURG.

Above is shown "Section E" of the winding department; below is a section of the "Detail Department." These are in wings of the main building, of which the center is shown on page 537.

tion which had been planned up to the time of its inception. Here again his courage never faltered, and the results have shown that it was not misplaced.

Another characteristic of Mr. Westinghouse stands out very prominently in connection with the next great development in alternating-current apparatus, namely, his willingness to examine promising schemes which are presented to his notice, and if, after careful examination, he believes them of value, to have no hesitation in spending both time and money in experimentation to develop them and bring them to complete success. As is well known, Mr. Westinghouse gave his help in this way to Tesla in the development of multiphase apparatus, and particularly what is known as the "induction motor," which really made the electrical transmission of power simple and completely successful. In this development Mr. Westinghouse's own practical skill and sound judgment were of great value. The same thing has occurred with a number of other devices which, although originated by others, have been brought to perfection by the experimental work carried on under the direction of Mr. Westinghouse and at his expense. A notable instance is the Nernst lamp, which seems destined to create a revolution in electric lighting, inasmuch as by means of this lamp a given amount of illumination can be secured with less than half the expenditure of current required by the best incandescent lamps. When Mr. Westinghouse secured control of the Nernst patents for America the basic principles of the lamp were known, but it was entirely a laboratory device, and anything but a commercial article. He put several of his brightest engineers and physicists, with the assistance of a corps of skilled workmen, at the problem of perfecting the details, and this has now been practically accomplished, after a large expenditure of money. There could not be a better illustration of the fact that the opinion so often entertained about inventions is entirely erroneous, namely, that some man by a happy thought, or an accident, makes a discovery which brings him in a large amount of money without any effort or expense. The development of the Nernst lamp has gone on for a long time, has involved a very large expenditure, and if its commercial development should result in a great reward it will have been fully earned.

Mention has already been made of Mr. Westinghouse's connection with signaling and switching pneumatically, and this has developed into another large industry—the Union Switch & Signal Company, with the details of which he is thoroughly familiar. Besides this, there is another large company called after him—the Westinghouse Ma-

chine Company—which manufactures steam and gas engines and steam turbines. The manufacture of steam engines was perhaps natural enough, although even here the Westinghouse engine is a special type designed to accomplish special results. The gas engine, however, might not be expected to be a necessary adjunct, but Mr. Westinghouse's work in developing the use of natural gas led him to realize the possibilities of the gas engine, and he himself believes that his work in this respect is likely to add as much to his reputation as the air brake. While following in some respects the standard form, the Westinghouse gas engine has some very important points of difference which have made it much better adapted to practical work than any of the forms which have preceded it. This receives a large amount of personal attention from Mr. Westinghouse, and he believes it is capable of still further improvement, which will make it a decided rival of the steam engine, if indeed it does not ultimately supplant it. It will occur at once to those at all familiar with the subject that for this to be a possibility there must be a cheap and available form of artificial gas, and it is pretty well-known to those interested in such subjects that Mr. Westinghouse has been successfully devoting his own attention, and that of an able scientific staff, to the development of such a form of gas.

It is not so well-known as it deserves to be that Mr. Westinghouse developed the use of natural gas so that it became the convenient servant which it now is to large areas quite remote from the immediate gas fields. The most important feature in the use of the gas (its piping from the gas wells) is due almost entirely to him, and indeed the Philadelphia Company in Pittsburg, which still controls the natural-gas distribution for that region, was created by him; he was until very recently its leading spirit, only severing his connection with it after the handling of the gas had been placed upon a firm basis and he felt that he could no longer give attention to this subject, because of the demand upon his time for his other interests.

Besides the great works near Pittsburg, which are best known to the engineering world, there are factories for the manufacture of the Westinghouse brake in England, France, Germany, and Russia, and there are now building in England works at Manchester, to be called "The British Westinghouse Electric & Manufacturing Company," where there will be manufactured the same articles as in the electric and machine companies in America. There is also a French Westinghouse Electric Company, with large works at Havre.

This is a very brief and wholly inadequate sketch of the work

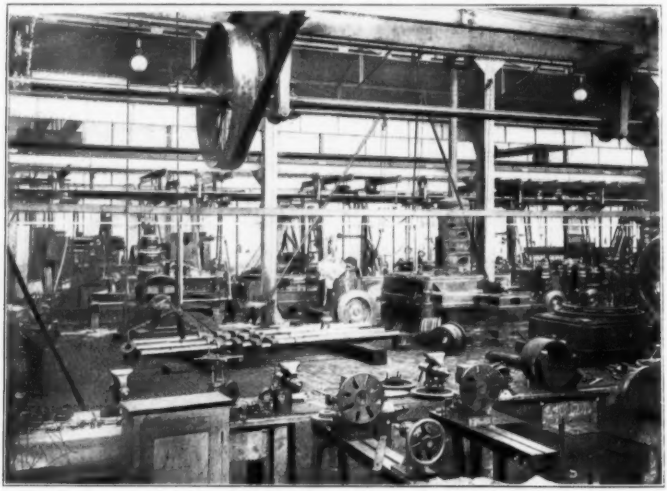
done by this wonderful man, who is not yet fifty-four years of age, but who has accomplished in thirty years more than almost any ten industrial leaders working each in one line have done in the same time; but the space permissible precludes a more extended sketch. No doubt it will be of interest, however, to state briefly what are the characteristics, as they show themselves to those who have been thrown with him intimately, that have contributed to his success and to making him one of the very foremost of the great captains of industry of our time. As showing his own modesty, it may be mentioned that Mr. Westinghouse himself attributes his success to hard work, and there is no doubt that this has been a very important element. Even now he works harder than any one of his many assistants, but it is, of course, obvious that hard work alone would not give such results. First of all comes his genius as an inventor. This was the foundation. Then comes intimate personal knowledge of mechanical processes and skill in the use of tools. It will have become evident in looking over the sketch of his life that no one but a man possessed of great intellectual capacity and keenness could ever have acquired the personal acquaintance with so many varied phases of engineering. This enables him to be the master of his great works, all of which he has personally planned, and those who know him best understand that, while he does not attempt to direct their routine, he nevertheless is fully acquainted with all the details, is able to discuss them thoroughly with those charged with their prosecution, and that he takes a keen personal interest in everything new and progressive, so that when he walks through his shops he knows just how work is going on, and if the progress has not been what it should be he calls attention to it at once. In this respect he is probably without a peer among the great industrial leaders. Many of them, as is well known, are not technical men at all, and those who are are limited to one particular line. As has been shown, the range of his knowledge covers a very large portion of the entire field of engineering.

It would be a very natural inference that a man of such great mental power and tremendous capacity for work must also be of powerful physique, and such is the fact. Mr. Westinghouse is a splendid type of physical manhood, standing over six feet, and would attract attention anywhere. It is this physique, combined with a temperate life and cheerful disposition, that has enabled him to endure the enormous work which he has already accomplished and is still doing.

Mr. Westinghouse has the true spirit of the inventor, combined

INTERIOR VIEWS IN THE WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY'S WORKS AT HAVRE, FRANCE.

with the keenest mechanical judgment as to usefulness and adaptability, so that he is always seeking improvement in the apparatus manufactured in his various works. It is this spirit which makes him willing to examine promising inventions by others, and when they commend themselves to his judgment he does not hesitate to spend



INTERIOR OF WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY'S WORKS, HAVRE, FRANCE.

time and money in their development. He is never willing, however, to attempt the commercial exploitation of any apparatus until it has been tested thoroughly, not only upon an experimental or laboratory scale, but on a working scale of large dimensions. This, of course, means the expenditure of large sums of money and the courage of one's convictions. The remarkable business talent, courage, and executive capacity of Mr. Westinghouse have already been mentioned, and undoubtedly these are extremely important factors in his success. There are numerous instances where great enterprises have been built up by business men, based upon the inventions or technical skill of others, but Mr. Westinghouse is the rare combination of the inventor with the keen man of business and the resourceful executive.

A striking illustration of his shrewd foresight, courage, and splendid common sense is shown in the planning of the two great establishments at East Pittsburg, Pa., the Electric and the Machine Works. These were built at a time of great business depression, and most people thought they were altogether too large for any probable

increase of business. Instead of a number of shops of moderate size, they were planned as a few large buildings, and room was left at both ends for extension when it became desirable. In five years after their construction, the extensions at both ends have been put on, owing to the growth of business, without any interference with the prosecution of regular work. The system of separate small buildings would have involved much greater expense with reduced efficiency.

One marked trait of character is his absolute integrity. Not a penny of his wealth has been acquired by stock manipulation or sharp practice of any kind. A very marked illustration of this could be told in a case where he disposed of his large interests in an enterprise of which he was the principal owner, and where, although he was offered a satisfactory price himself, he refused to sell until exactly the same offer had been made to all the small stockholders. These believed in him and had made their investment because he was directing the enterprise, and his loyalty to those who had trusted him made him look after their interests until he was sure that they could be placed beyond any mishap.

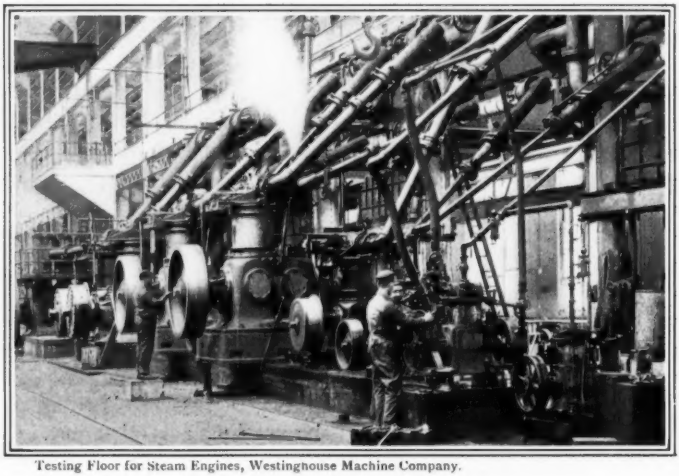
It might be possible for a man to possess all the characteristics which have been mentioned and still fail of complete success, for, after all, with such varied interests the man of greatest capacity must depend upon subordinates for carrying out his ideas; but Mr. Westinghouse has other characteristics which attach to him his subordinates, so that he is sure of the most faithful and loyal service. His sympathy, kindness, and tact in his relations with his subordinates are remarkable and make him personally one of the most agreeable and attractive of men. The popular idea, perhaps, of a man who has done such wonderful work and achieved such distinction is a man inaccessible to all except others of his own standing, and one whom subordinates would approach with fear and trembling. Nothing could be wider of the mark than such an idea as applied to Mr. Westinghouse. His subordinates are all his friends, thoroughly devoted to him, and counting it a pleasure to give their very best efforts to increasing his success. He is exceedingly hospitable, and while at his home in Pittsburg is fond of surrounding himself with his lieutenants and younger assistants, who always enjoy an evening spent with him, which usually involves a very interesting discussion of the latest developments in science and manufacture.

As already intimated, Mr. Westinghouse is an extremely modest man, and, while fond of entertaining and of making others happy, is altogether averse to mere display or ostentation. He is very generous

in a quiet way, in which he has the hearty co-operation of his charming wife. He has one son, who is just about to enter college.

During nearly all of Mr. Westinghouse's mature life his home has been in Pittsburg, and in view of his great enterprises, of which that city is the center, employing more than ten thousand operatives and having a capital of over fifty millions of dollars, it can readily be understood that he is one of the great men of the city and highly esteemed by all the citizens.

It is difficult in writing about such a man as Mr. Westinghouse to avoid the appearance of overdoing the matter and running into mere laudation, but this is simply because his career is so remarkable a one and covers so wide a field of effort. Those who know him best will say that this sketch is altogether inadequate and by no means does him justice. There are, indeed, many interesting events in his history which if related would shed still more light upon the qualities that have contributed to his success, but enough has been said to give some idea of the man and his work. There is much in his career to encourage all young men, for some of his merits are the homely ones which all may cultivate. The remarkable combination, however, of great business ability and executive capacity with inventive genius and technical skill is so rare that we realize these are gifts of nature, and are the qualities which enable a man to inscribe his name high up on the roll of fame and to become one of the great benefactors of humanity.



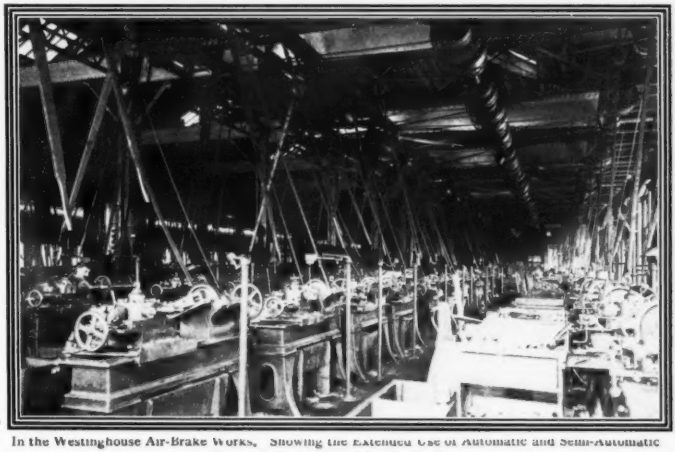
Testing Floor for Steam Engines, Westinghouse Machine Company.

GREAT WORKSHOPS OF THE WORLD.

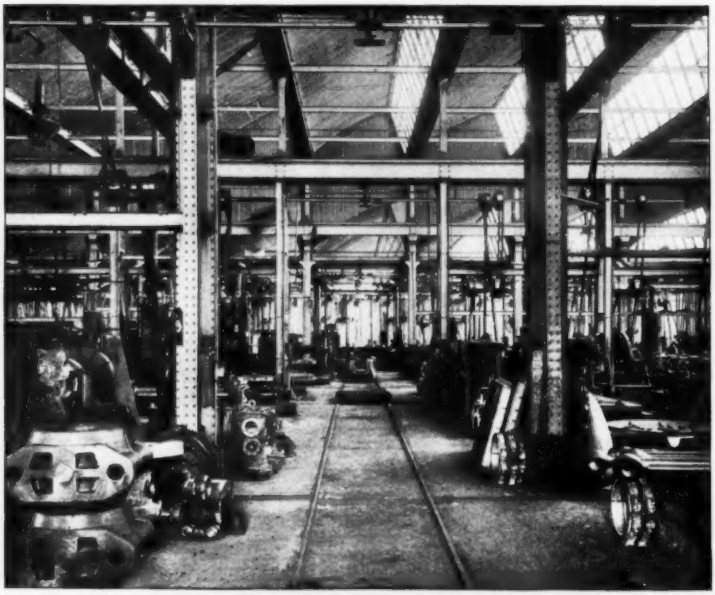
A Series of Photographic Reproductions.

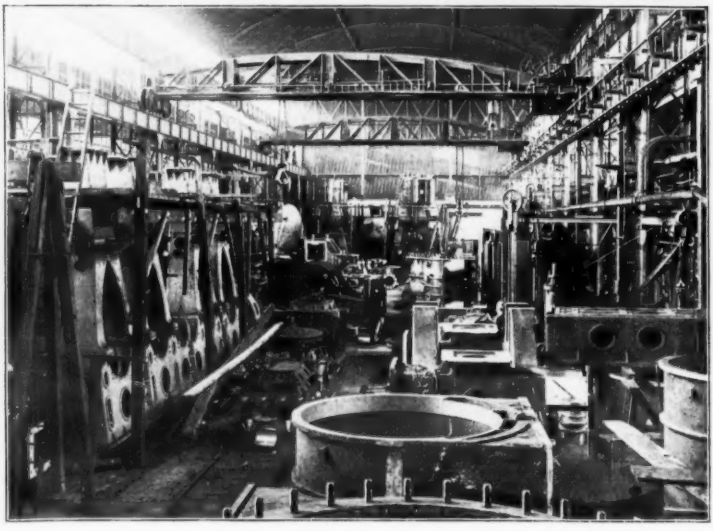
DESCRIPTION and direct illustration of highly-successful plants have peculiar value for the practical man. In the following pages of engravings, and in similar groups further on in the volume, there are brought in the concrete before the eye of the reader the general arrangement, the special equipment, or the characteristic features of a few of the foremost engineering and metal-working establishments of Europe and America.

Thus, in supplement to the four preceding critical reviews, a panorama is afforded of the most interesting sections or most suggestive features of the world's large workshops. The story of the pictures is made clear by explanatory comment beneath, and the utmost use is thereby made of the available space. It is clearly impracticable to include more than the very greatest establishments—those which by the magnitude of their operations, the range of their distributed products, or the excellence of their output, have become typical of the industrial progress of the land where they have their home. They epitomise the practice of works management, the principles of which are formulated and codified in every issue of THE ENGINEERING MAGAZINE.



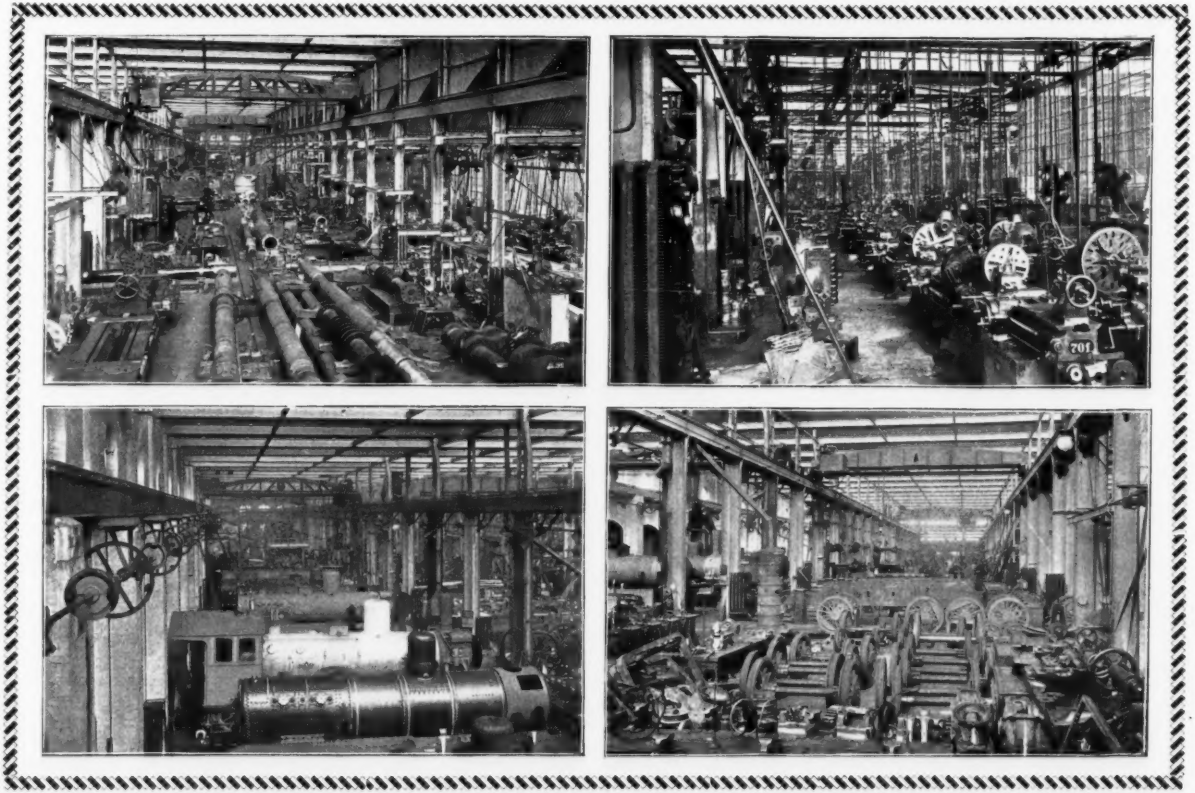
In the Westinghouse Air-Brake Works. Showing the Extended Use of Automatic and Semi-Automatic Turret Lathes in Repetitive Production.



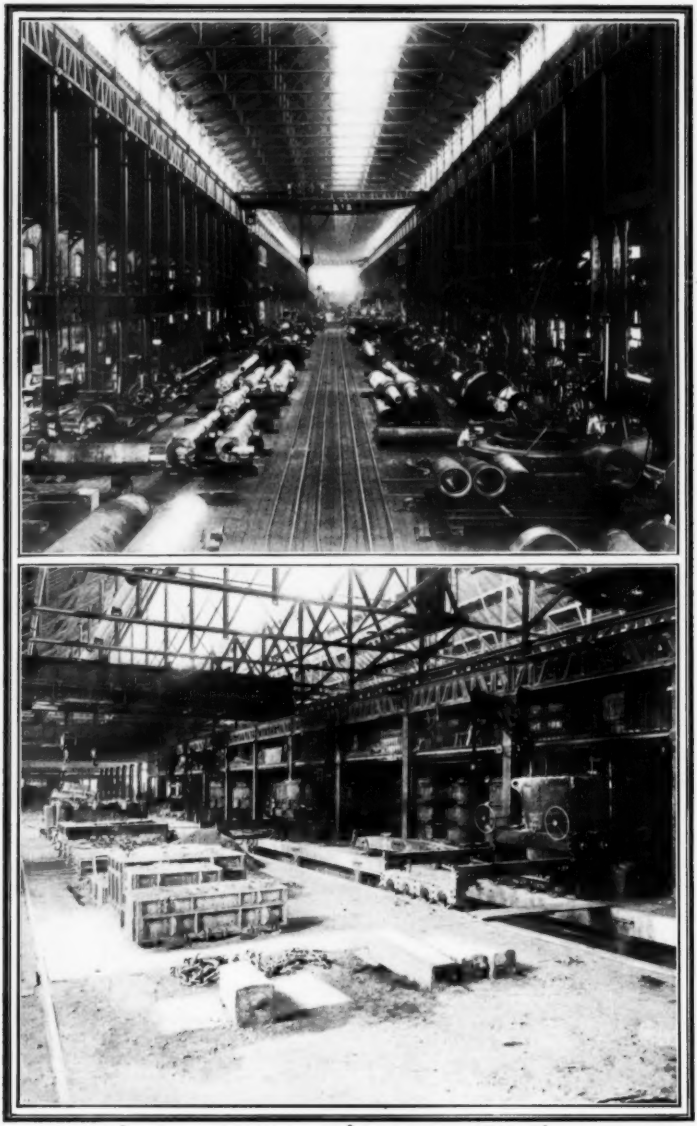


LATHE SHOP AND PART OF ERECTING SHOP OF THE VULCAN WORKS AT STETTIN, GERMANY, THE BUILDERS OF THE TRANSATLANTIC RECORD BREAKERS DEUTSCHLAND AND KAISER WILHELM DER GROSSE.

Germany's industrial rise is nowhere more marked than in marine construction. Illustrations of her mechanical progress are therefore fittingly drawn from the champions in her struggle for supremacy on the sea.

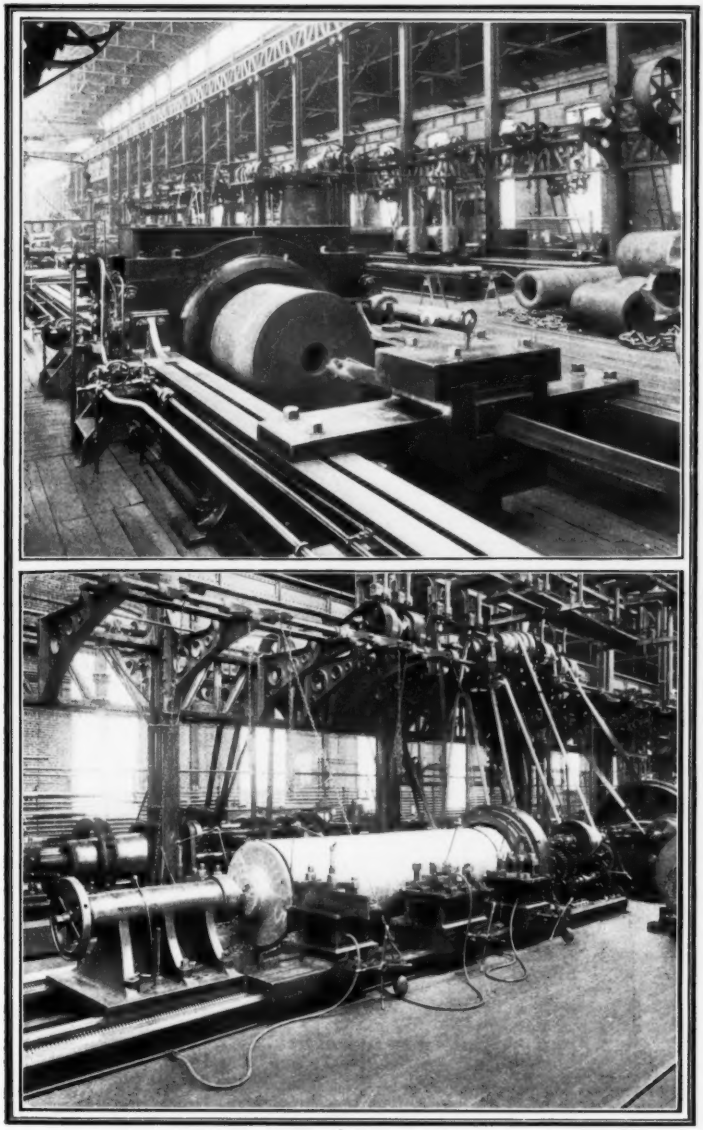


FOUR BAYS IN THE LOCOMOTIVE AND LATHE SHOPS OF THE VULCAN WORKS AT STETTIN.



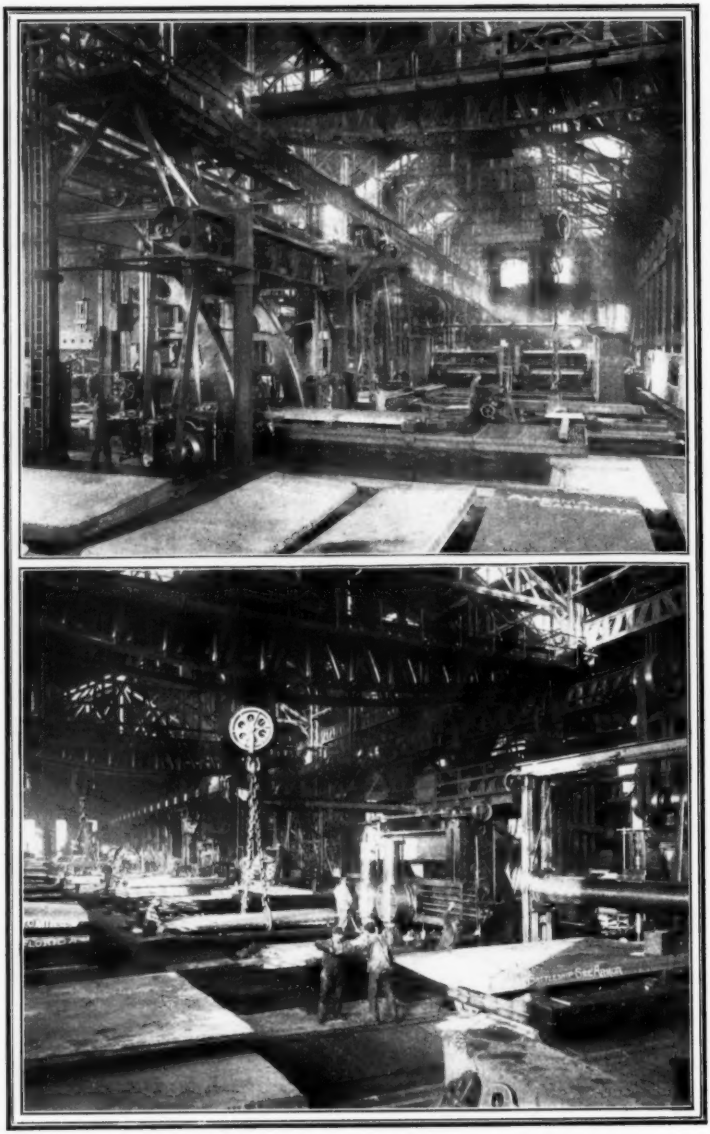
PLANT OF THE BETHLEHEM STEEL CO., SOUTH BETHLEHEM, PA., U. S. A. OPEN-HEARTH FURNACES AND GUN-FINISHING MACHINE SHOP.

This company shares with Carnegie the largest contracts for armour plate, and leads American plants at least in the making of ordnance. The open-hearth plant is 62 feet long, and contains one 10-ton, one 20-ton, and four 40-ton acid and two 40-ton basic furnaces, with Siemens' gas producers. The gun-finishing shop is a sub-department of the main shop shown on page 552. It contains all machinery necessary for finishing the parts of guns of all calibres, before and after assembling, as well as their breech mechanism. Gun carriages and mounts are assembled here.



CUTTING AND BORING A FLUID-COMPRESSED INGOT, BETHLEHEM STEEL WORKS, SOUTH BETHLEHEM, PA., U. S. A.

After clearing the sand from an ingot, it is swung in a powerful lathe and cut into blocks of the length requisite for the forgings desired. For hollow forging, the center of the block is bored out on a horizontal boring mill. The one shown has a central driving head, with boring bars at both ends, and takes work 60 inches diameter, boring a 20-inch hole.



VIEWS IN THE MACHINE SHOPS OF THE BETHLEHEM STEEL CO.

The armour-plate shop, above, is equipped with tools of enormous size and power, together with portable drill presses, grinders, etc. Here the groups of armour are assembled in the position they will occupy on the vessel, and are finally inspected. The general machine shop, below, is the heaviest of the plant, being 1,375 x 117½ feet. It is of steel and brick, with a central span of 60 feet, served by six electric cranes of 25 to 75 tons' capacity; there are four 10 to 25-ton electric cranes in the side aisles.

USES AND ABUSES OF ORGANISATION AMONG EMPLOYERS AND EMPLOYEES.

WHAT EMPLOYERS MAY PREVENT AND EFFECT BY UNITED ACTION.

By Sir Benjamin C. Browne, D. C. L.

PROBABLY we still all agree that in Great Britain the period from the conclusion of the great engineers' strike in February, 1898, up to the summer of 1900 has been very free from disputes, compared to any other period where there was an equal demand for labour. Not only has the engineering trade been very busy, but nearly all other trades, especially all branches of iron trade, coal mining, and building, have been at an extraordinary pressure. The war in South Africa has added to the pressure and reduced the available amount of labour, and yet things have kept quiet, and it is now our business to consider if this is due in any degree to the way in which the strike was settled, and if so, to what extent.

Now as there is no official manifesto on the part of the employers stating their views on the question, it is to be clearly understood that no paper can be more than the view of a private individual, who, however well informed he may be, can only speak of what he sees himself and the ideas he has formed thereon.

It may be well just to call the reader's attention to some of the main features of the strike that began in July, 1897, and ended in January, 1898. For a long time there had been great tension and frequent disputes between the Amalgamated Society of Engineers and

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The most striking and most important tendency of the times is that toward concentration—toward the gathering of smaller units into centralised or harmonised bodies—toward the blending of many individual forces into a great single unified power. It shows in the federation of states, in the rapid growth of cities, in trade combinations, in the centralisation of the power plant, in the labour-union movement, and still more lately in employers' associations. The organisation of manufacturers and workmen, in which some have feared lay the menace of industrial war, far-seeing leaders look upon as the most hopeful foundation upon which to build a peace which shall be lasting because it is just—because organisation so consolidates both interests into tangible, responsible bodies that complete conference, mutual understanding, and trustworthy agreement become possible. There is no more interesting topic in the whole labour question than is here discussed by Sir Benjamin Browne, as an employer, and in the succeeding article by Mr. Barnes, as a labour leader.—THE EDITORS.

their employers, chiefly, but not entirely, on questions connected with shop management. The districts chiefly involved in them were the Tyne, Wear, Tees, Clyde, Belfast, and Barrow, spreading onwards into Yorkshire. A conference was held about Easter, 1897, in Westminster, at which some matters were provisionally settled; but the eight-hours question cropped up in London, and the employers, believing this likely to be a national question, took up the cause of the London firms and locked out in their support. Numbers of other employers in various parts of England joined, and the matter became a trial of strength between the Amalgamated Engineers, the Steam-Engine Makers, and some other unions, and their employers. To pass over the history of the struggle, the eight-hours demand was withdrawn in January, 1898, and certain terms were agreed to in conference, called the "Conditions of Management." If we wish to follow the industrial history of the trade, we must dwell on these a little. The employers honestly believed that a large discretion as to works management must be left with the employer, who is responsible for all taking of orders, competition, prices, excellence of work, profit and loss. But the following extracts will give a clear idea of the settlement:

"GENERAL PRINCIPLE OF FREEDOM TO EMPLOYERS IN THE MANAGEMENT OF THEIR WORKS."

"The federated employers, while disavowing any intention of interfering with the proper functions of trade unions, will admit no interference with the management of their business, and reserve to themselves the right to introduce into any federated workshop, at the option of the employer concerned, any condition of labour under which any members of the trade unions here represented were working at the commencement of the dispute in any of the workshops of the federated employers; but, in the event of any trade union desiring to raise any question arising therefrom, a meeting can be arranged by application to the secretary of the employers' local association to discuss the matter.

"Nothing in the foregoing shall be construed as applying to the normal hours of work, or to general rises and falls of wages, or to rates of remuneration."

"1. Freedom of Employment.—Every workman shall be free to belong to a trade union or not, as he may think fit.

"2. Piece Work.—The right to work piece work at present exercised by many of the federated employers shall be extended to all members of the federation, and to all their union workmen.

"3. Overtime.—When overtime is necessary the federated employers recommend the following as a basis and guide: That no man shall be required to work more than 40 hours overtime in any four weeks after full shop hours have been worked, allowance being made for time lost through sickness or absence with leave.

"4. Rating of Workmen.—Employers shall be free to employ workmen at rates of wages mutually satisfactory. They do not object to the unions or any other body of workmen in their collective capacity arranging among themselves rates of wages at which they will accept work, but while admitting this position they decline to enforce a rule of any society or an agreement between any society and its members. General alterations in the rate of wages in any district or districts will be negotiated between the employers' local association and the local representatives of the trade unions or other bodies of workmen concerned.

"5. Apprentices.—There shall be no limitation of the number of apprentices.

"6. Selection, Training, and Employment of Operatives.—Employers are responsible for the work turned out by their machine tools, and shall have full discretion to appoint the men they consider suitable to work them, and determine the conditions under which such machine tools shall be worked. The employers consider it their duty to encourage ability wherever they find it, and shall have the right to select, train, and employ those whom they consider best adapted to the various operations carried on in their workshops, and will pay them according to their ability as workmen.

"Provisions for Avoiding Disputes.—With a view to avoid disputes in future, deputations of workmen will be received by their employers, by appointment, for mutual discussion of questions in the settlement of which both parties are directly concerned. In case of disagreement the local associations of employers will negotiate with the local officials of the trade unions. In the event of any trade union desiring to raise any question with an employers' association, a meeting can be arranged by application to the secretary of the employers' local association to discuss the question. Failing settlement by the local association and the trade union of any question brought before them, the matter shall be forthwith referred to the executive board of the federation and the central authority of the trade union; and pending the question being dealt with, there shall be no stoppage of work, either of a partial or a general character, but work shall proceed under the current conditions."

"NOTE—A grievance may be brought forward for discussion either by the workman individually concerned, or by him and his fellow workmen, or by the representatives of the union.

"In no instance do the federated employers propose conditions which are not at present being worked under by large numbers of the members of the allied trade unions. The federated employers do not want to introduce any new or untried conditions of work, and they have no intention of reducing the rates of wages of skilled men.

"These conditions, with relative notes, are to be read and construed together."

The above are extracts and not a complete copy. The most interesting and important point is that called "provisions for avoiding disputes," as great numbers of vexed questions have under these been brought before the central authorities of the two sides, and have been settled peaceably. Of course, this may not always be the case, if the court of final appeal cannot agree; there is nothing beyond it, and a trial by force might again arise.

Some of these conditions the men avowedly dislike, and in other cases they object to the interpretation put on them; the agreement very possibly needs revision in detail, but there ought to be no difficulty, either in engineering or any other trade, in arranging terms which would be fairly satisfactory to an unprejudiced mind.

Personally I think that the above, if not perfect, was at any rate a genuine step in the right direction, and if the working out has not always been so satisfactory to the men as they might wish, it must be remembered that after a struggle it is very seldom that the defeated party is able to meet the winners quite on equal terms.

But, as it is quite obvious that a strike is the result of very serious divergence between the views of employers and workmen, perhaps the fairest way to look on the question is to consider first what would be the ideal position for the employers and workmen to occupy between themselves, and then see how near we have approached this ideal.

I have always held, and I believe most fair-minded employers and workmen hold, that the best position for negotiations to be carried on between capital and labour is that of *absolute equality*, and that neither side ought to wish to have any advantage over the other, and if all questions could be settled on the basis of justice, fair play, and the general good of the trade, it is quite clear the question as to which was strongest would not be of any importance, or enter at all into the calculations of either side. It is only because of the possibility of an appeal to brute force that these things have to be borne in mind.

I fear we are a long way off this ideal, but there is no doubt that every step towards it is a very great gain to both sides and to the prosperity of the country; and I may say, as I have often said before, that I do not think on the whole the relation between employers and workmen is so unsatisfactory as it is sometimes said to be. There are probably at least six million males in the United Kingdom, working as mechanics or labourers. Each of these men has his own difficulties, his own feelings and prejudices, and probably every now and again some real hardship and sometimes injustice to be borne; and I think on the whole the wonder is not that we sometimes have strikes and difficulties, but rather that we do such an enormous amount of work so smoothly as at present.

For example, the engineering, and ship-building, and I might add the coal and iron trades, have gone through a time of unprecedented prosperity and high pressure since the beginning of 1898, and during that time there has been comparatively little friction; there has been regular employment, and a very large amount of work has been turned out, presumably to the satisfaction of the purchasers.

Our difficulties, speaking both for ourselves and our workmen, attract attention on account of the number of us there are in the world, and therefore the absolute size and frequency of these disputes, not on account of their relative size and frequency; compared to our numbers, I think the proportion of difficulties that are not settled amicably and by mutual forbearance is very small indeed.

Of course, one great point is to make up our minds whether we think it better there should be trades unions or not. My own feeling has long been that large unions, both of workmen and of employers, are by far the most satisfactory. All disputes then, before they can lead to stoppages of work, are taken away from the original disputants and are brought before selected employers and workmen of knowledge and experience in dealing with such matters; men who know each other well personally, and who have usually established a friendly and to a great extent confidential footing with each other, and numbers of disputes which would lead to a stoppage of work, if they had to be settled between an employer and workmen in the works, get smoothed away and settled amicably by the time they reach the last court of appeal.

The late Col. Dyer, whose name was so well-known during the strike of 1897, was always very anxious to keep to the front the fact that the employers did not want to smash the trades unions. I think the settlements that he made, not only in connection with this strike

but on previous occasions with the boiler-makers and other bodies, showed that such was his consistent conviction, and the special settlement after the 1897-1898 strike as above shown proves this conclusively.

The demands which may be made by workmen and cause friction may be roughly classified under four heads:—

1. Demands which benefit the workman, and are not injurious to the employer.

Personally under this head I should include such a matter as weekly pays. They were a certain amount of trouble to introduce, and no doubt they involved a certain, but not a large, amount of extra expense; but I think it is a very great benefit to the workman to be paid as often as possible, and I think his money goes further, so that the remuneration paid, without costing the employer appreciably more, is of really greater value to the workman, and so the service in which he is engaged is made more attractive without increased expense.

2. Demands which are beneficial to the workmen, and which at a greater or less sacrifice the employers can afford to give.

Such as this would be a moderate rise of wages.

3. Demands which are beneficial to the workmen but which the employer cannot afford to give, either on account of his own interests or on account of the trade.

Under this head would come a large increase of wages, which would more than absorb the employer's profits, or compel him to put up prices so high that it would throw a large number of men out of work.

4. Demands which are not really beneficial even to the workmen.

Under this head I should put all the demands for restriction of labour, such as restricting the amount of work a man is allowed to do, either as regards quality or quantity, all of which make his services less valuable and must in the long run reduce his own money value. Limitation of apprentices would also come under this head.

Of course it is impossible that all employers, and very much more impossible that all workmen, should think the same, and it is therefore wise to encourage the freest discussion and the freest individual expression of opinion, because the strength of either side is not that all the employers, or all the workmen, think exactly the same, but that they are prepared to defer their individual views to those of the majority.

To refer to those who suppose unions are an evil. I think they

take as an ideal some self-reliant workman, who has a very strong character, great self confidence, who can make his own bargains, and then they say: "If all men were like that how nice it would be." But they must know that all men are not like that. People who can take the lead and act entirely on their own self-reliance are very scarce in every relation of life, and what used to happen much more before unions were so strong was, that suddenly a feeling would rise up among a body of workmen that they were dissatisfied or offended, and that they ought either to have a large rise of wages or something else. A mass meeting would be called by the most violent of them, and the most extreme would force themselves to the front, the delegates would be elected by clamour, and then come as the representatives of the whole party of the workmen, saying they must have the most unreasonable concession or they would go on strike, and take such courses as a wise trades-union leader would never adopt. I think anyone who has known the labour market for the last thirty years will say that the demands are almost without exception far more moderate in their character than they used to be before the men were so much under the influence of the unions.

The emergency committee, which is the court of final appeal, usually consists of about a dozen members, half of whom are the leading members of the central council of the Amalgamated Society of Engineers, and the other half are selected engineer employers.

The questions that come before the committee may refer either to districts, single works, or individual men; they may be questions of wages, hours of work, allowances, or cases of misconduct, unfair treatment, or anything else.

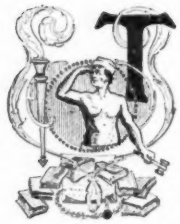
It is, I think, a great gain to the men to feel that if any one of their members is harshly treated his case can be brought up before this highest appeal, and the possibility of having to justify one's action before such a tribunal must act as a controlling influence on every employer. I hope that harsh treatment of workmen has never been common, but this ought gradually to make it impossible.

We employers cannot speak as to what the workmen think of us, but there is no question that Mr. Barnes, the well-known secretary of the Amalgamated Society of Engineers, Mr. Sellicks, the president, at whose return to our meetings, after a long and serious illness, we all so much rejoice, and many of their colleagues, have impressed the employers very favourably by the way with which they have dealt with the various questions that have come before us.

USES AND ABUSES OF ORGANISATION AMONG EMPLOYERS AND EMPLOYEES.

THE OLD TRADE UNIONISM VS. WISELY-ORGANISED LABOUR.

By George Nicol Barnes.



TRADE unionism in Great Britain dates from the rise of the factory system of industry, the first twenty-five years of which were marked by an unexampled increase in the productivity of labour and a like increase of misery and degradation among factory operatives. In the absence of organisation, the new conditions told almost entirely in favour of the employing classes, and those who decry trade unionism would do well to cast their minds back upon that period of unrestrained competition and make themselves acquainted with its relentless greed and biting poverty. Each employer had become, for the first time, a combination of employing power, and most employers subordinated every other consideration to a desire and determination to amass wealth.

Trade unionism was at first, however, but a crude attempt on the part of isolated groups or unions of men to maintain, or rather to re-establish, for themselves the old economic relationship. Political power was in the hands of the monied classes and had long been used as an instrument of oppression; public opinion was sluggish and wholly-uninformed as to the new industrial methods; hence trade unionism sought neither to utilise the one nor conciliate the other. Laws and learning had no attractions for the early unionist, and the greatest favour asked of either was to be left alone. Unions were, in fact, local and sectional in character and unionists were individualistic by instinct, having but little knowledge of the nature of the forces they were invoking, but driven to combination as a means of protection against harshness of industrial conditions. Time and the logic of events have changed the situation. Political power has passed into

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It is most gratifying to see how nearly the ideals of advanced labour, as sketched here by a leader like Mr. Barnes, correspond with those of the employer, as set forth in the preceding paper by Sir Benjamin Browne. The reason is plain—both are conceived primarily in an earnest striving for right and justice. The situation, as it appears in the light of these two reviews, is full of hope and promise.—THE EDITORS.

the hands of the people and public opinion has become more alert as well as better informed. At the same time trade unionism has widened out in structure and in aim, now aspiring to regulate industry as well as to influence public opinion.

Turning now from generalities, let me endeavour to give a more-detailed statement of the principles and conditions upon which trade unionism is based. It assumes two things: first, that each class in the community—or at all events, the great mass of each class in the community—will always follow the line of self interest; and second, that workmen as a class, by reason of numbers and dependence and circumscribed lives as compared with other classes, must be organised in order to make their power and influence felt. And upon these two a third idea is being forced, alike by industrial development and by spread of altruistic teaching, viz., the unity of interest of all labour, whether of hand or brain. We have travelled far on the road to collectivism since the advent of the factory system of industry. Employers themselves have organised, first locally and then nationally, and the units of employing power have become larger with the centralisation of business in fewer hands. Still, trade unionism has maintained its character throughout as essentially a class movement, tending, however, to become a movement covering and working for the whole class instead of certain sections of it only. The groups have become larger in themselves, and, by absorption and amalgamation, fewer in number. In the last five years the number of unions has decreased from 1,317 to 1,267, while the number of unionists has increased from 1,404,898 to 1,644,591, some 400,000 men being enrolled in a federation of unions started a year ago. The distinctive features of the newer organisation have been the supercession of localism and the systematising of the principle of provident funds for the purpose of ensuring unionists against sickness, unemployment, or exceptional misfortune, as well as of providing annuities for old age.

Wider experience and fuller resources have been brought to bear on the settlement of local disputes, solidity and discipline have been added by the acquiring of vested interests in old-age funds through long years of membership. In this process of development the engineering unions have taken a leading part. Fifty years ago many of the local and sectional societies in the trade became merged in the Amalgamated Society of Engineers, which was the pioneer of the national societies. These national societies, like a modern Aaron's rod, have swallowed up most of the local and sectional societies which had existed fifty years ago, and are to-day the distinctive type of

English trade unionism, the Amalgamated Engineers being the largest, with a membership of 86,000. During the early part of their existence agitation was successfully directed to the abolition of such laws as still militated against freedom of combination and security of funds, and the last few years has witnessed increased attention being paid by them to the raising of the standard of life through the direct agency of public bodies, and the bringing together of all labour—skilled and unskilled—into closer union.

Let me here note a wide-spread fallacy frequently met with in the columns of technical journals like THE ENGINEERING MAGAZINE. The new unionism is frequently held up to opprobrium as the disturber of the peace in questions of demarcation of work and kindred troubles. The exact opposite is the fact. The new unionism seeks to prevent labour organisations being pitted against each other. Its leaders have actively opposed the fomenting of squabbles between rival trades. If at any time it has backed up the old unionism against an incursion of unskilled labour into a trade, it has not done so for the purpose of seeking privileges for one section at the expense of other sections of labour, but because convinced that such incursion would lead to over-specialisation with attendant evils. It accepts specialisation as inevitable, but desires to regulate the application of the newer methods arising therefrom, so as to make them harmonise with wider interests than those arising from mere considerations of production.

Again, the new unionism is often charged with restricting production so as to spread work and employment over a larger number of men. This may have been at one time and for the reason stated, and it should not excite surprise if workmen had thus interpreted the theories once current as to the sources of wealth and wages. Trade-union organisation has certainly been used at times to cover up malingering, but this by no means implies that trade unionism is responsible for a disposition, common to human nature, to rub along through life as comfortably as possible. It is no part of trade unionism, either old or new, to restrain production below a point consistent with the requirements of health and permanent efficiency. And the new trade unionist, at all events, knows full well that the larger his production the larger, other things being equal, will be his wages. But, while believing in a fair day's work, the trade unionist declines to be entirely guided by short-sighted views of production. He bases his case upon the broad basis of humanity, refusing to regard himself or his fellows as mere wealth-producing machines. Trade unionists, both old and new, claim for workmen a voice in the fixing of the general conditions

under which they shall work. Both are alike interested in protecting workmen from the admitted evils of piece work, from over specialisation of industry, from long hours of labour, and from low wages. If there is any difference between them on these points, it can be summed up in the different importance which each may assign to them.

It will, I think, be generally admitted that trade unionism has substituted discussion for violence in the settlement of disputes, and that it has enabled its leaders to acquire that caution and moderation which comes with a wider knowledge of affairs. But be it remembered that the safeguarding and promoting of the interests of workmen are its chief concern, and industrial peace only in so far as such is consistent therewith, as well as with conditions of employment which will bear the test of examination from the point of view of the workmen's interest. Unfortunately it cannot be said that the rules or terms of agreement to which the engineering industry of Great Britain is supposed to be at the present time working are consistent with the safeguarding of labour interests. Some three years ago, the engineering employers entered into a solemn league and covenant against the lessening of hours, and to secure for themselves absolute discretion in the disposition of labour in their workshops. After a seven-months' stoppage, work was resumed upon terms of settlement which, though considerably short of those originally attempted to be imposed on the men, still appeared broadly to give the employers the disposal sought. Whereupon there was much rejoicing among most, and a little boasting on the part of some, employers at the great victory achieved, and we were told that capital was henceforth to be "absolute master" and that labour was to be treated as an "inert mass." But alas for the vain delusion! I venture to say that the terms of settlement do not contain the elements of permanency and that in some respects they run counter to the reason and sense of justice of the great mass of engineering operatives, and even, I believe, of many of the employers themselves. Let me deal with them on two points: 1, Piece work, and 2, Machinery.

There are two ways only by which piece work can be wrought smoothly and with permanent advantage to employers and employed. Where standard price lists are possible, such may be arranged or agreed to by the employer and the union, and each man or group of men then be left to his own or their own resources. The alternative method—applicable where work is not sufficiently-standardised to admit of price lists—is that the employer should himself price the work (individual bargaining really amounts to that) but guarantee a certain minimum wage which should, I think, be a certain percentage

over and above the day-work rate. The former method safeguards collective bargaining as applied to standardised work. The latter safeguards the interests of both sides in the fixing of prices of other work, as it protects employers against workmen by the stimulus given to the latter to earn more than the guaranteed wage if the price will admit of it, and it protects the employed against employers inasmuch as, if employers reduce prices to that point which will just yield the day-work rate, workmen will drop into day-work speed and effort. Employers object to this guaranteed wage, because, they say, workmen have been content with such wage and have not exerted themselves to earn more when such wage was guaranteed. But surely such an argument from employers carries its own refutation and moral. It is a proof of the soundness of the workman's position, since it proves that employers had cut down prices to a point at which it was not possible to earn anything for extra effort. It is inconceivable that workmen would refuse to increase their earnings if they had a chance of doing so.* The Employers' Federation refuse to recognise or concede either of these two methods of payment of piece workers, and, as a result, workmen object to piece work altogether, though it is but fair to say that the practice of many employers has been a good deal better than the precept of the organisation of which they are members.

In regard to machinery, the federated employers claim to exercise a right to place any workman, irrespective of age or previous training (or the want of it), at any of their machines and under any conditions without objection being raised by the union. We hear much from some in advocacy of the "group" or "American" system, a feature of which we are told is the placing of a group of machines under the charge of one skilled piece worker with helpers. This system, it is said, leads to increased efficiency and therefore to increased employment, owing to an increased demand. It seems to be forgotten that it is not so much the amount of employment as the nature of it which forms the basis of the men's objection to the general adoption of this system. The enquiry naturally suggests itself to my mind as to whether or not there is any apprentice system in America and if so, to what are the lads apprenticed? It seems to me that, if what we are told be true, then the American workshops must be nearly filled by

* Inconceivable as this seems to a leader of Mr. Barnes' ability, or to any reasonable thinker, it has nevertheless remained for American organised labour to commit exactly this folly in its stubborn opposition to the premium plan. See Mr. Norris' paper on Actual Experiences with the Premium Plan in THE ENGINEERING MAGAZINE, Jan., Feb., 1900.—THE EDITORS.

what in Scotland are called "halflins" (*i. e.*, half men) regimented by a few overlookers with an eye to bonus. I have not been to America, so that this may be a mistake on my part—perhaps the system, if in general vogue, may be carried out as an alternative to apprenticeship.

I do know that it is a laudable ambition on the part of British parents to give their lads a trade, and much sacrifice is made to do so, lads being put to the trade at very low wages (I myself started at 2s. 3d. per week, and I have a lad in his seventeenth year earning only 4s. per week). Surely employers who benefit by this cheap labour should admit its right afterwards to a voice in regulating the trade in which it thus acquires an interest. At all events, it is clear to my mind that the probationary servitude of lads in Great Britain entitles them in after life to take such steps as may be necessary to protect the trade from microscopic subdivisions which would reduce mechanics to mere machine-tenders, doomed to a dull round of narrow and uninteresting drudgery. The group system is applicable and, as a matter of fact, has been applied in Britain, without detriment to anyone, in the manipulation of automatic or semi-automatic tools, but its application to tools of a wide range of work is objected to by workmen as being, in their belief, unfair in principle and of more than doubtful advantage in practice, judged even from a productive point of view. At the same time, I freely admit the right of the employer to exercise an initiative in these matters, and I believe there has been, in times gone by, an undue interference with this right; but I submit that smooth and satisfactory working is not more likely to be attained by pushing things to one extreme than to the other. There is much to be said for a grading of labour and for its payment in some approximate proportion to skill; but, on the other hand, workmen have a right to expect that the interests of labour and of the community shall be considered, as well as those of the employers, in the manning of machinery. The time has long since gone when a mere assertion of ownership sufficed to justify absolute disposal of anything, when such disposal affects large numbers of people.

True, there are the "courts" for "avoiding disputes" and I want to say nothing which would seem to under-estimate their value. They have brought employers and employed together and enabled them to understand better each other's difficulties; they have accustomed both to reason out their differences, and they have averted stoppage of work and loss to all which comes with stoppage. But after all, they have their limitations. As at present constituted they but enable each side to ascertain the strength of the other as indicated by the perti-

nacity with which it clings to its argumentative position, and so they lead to avoidance of disputes as much through the wholesome fear of losing money as by any other consideration. They presuppose a right on the part of the employer to "do what he likes with his own," and they further, in certain respects, reserve to the employer the power of substituting individual for collective bargaining at will; on the other hand, they provide no reservation for workmen, either for reference in case of disagreement or for the maintenance of minimum conditions. Such "courts" can never reconcile conflicting interests; they cannot even exhaust the means of amicable and just settlement of disputes, since workmen sitting upon them know little of prices and less of profits, while the employers know everything of both and of wages as well. Hence the need for a "third party," fully informed, whose decisions would be more likely to be impartial because untainted by considerations of self-interest. Organisation will, I believe, necessitate a resort to arbitration courts in some shape or form. Conciliation boards are but half-way houses. Some day the community will step in and assert its right to a say in the matter. Probably this was undreamt of in the philosophy of the early organisers, either of capital or of labour, but it must be the ultimate outcome of the existence of rival organisations able to inflict injury upon industry in all its branches. Meanwhile there are problems confronting the trade which will be solved neither by masterful assertiveness nor by plausible theories contrary to the light of facts. In THE ENGINEERING MAGAZINE, May, 1900, I note that Mr. Charles Buxton Going predicts for specialisation but one outcome, viz.: "The raising of the former partly-skilled attendant to the grade of a far more highly-skilled tool-maker and designer." Mr. Going is evidently possessed of the faith that moves mountains, and endowed with the cheerful spirit of the man who was content that he had a whale of his own in the North Seas.*

Specialisation in the past has had no such result as predicted for it in the future, and, in the nature of things, it cannot have any such result. In the past specialisation has resulted in narrowing the field of individual activity of the mechanic. In the future, while making labour less varied, it may also make it more easy; while making labour more productive it may abridge—and should ere now have abridged—the working day; but to argue that specialisation will "raise" the mass of labour out of itself denotes a mere optimistic delusion.

* Mr. Going rejoins that this is preferable to the pessimism which refuses to believe there are any whales anywhere. The question, however, is admirably discussed by Prof. Higgins in the following article.—THE EDITORS.

It has been stated more than once in the columns of THE ENGINEERING MAGAZINE that the 1898 terms of settlement have caused some wonderful changes in the workshop and that they have "emancipated" industry from "pretensions" and "tyranny," from "drags and chains," and various other curious things said to be part and parcel of trade unionism. Of course the fair-dealing employer knows all this to be for the most part pure nonsense, and that it is just such writing as leads to friction. British employers generally know full well that there is but little practical difference in the workshop now, as compared with the time prior to '98, and that the real solid gain following the dispute has been the freedom from stoppage, consequent upon the facilities afforded for the discussion of differences.

I want to see those facilities maintained and even made better; I want to see them made the media by which the wisest counsel on each side may be made effective. Organisation on both sides on a large scale has for the first time made this possible, and the far-seeing men on either side will endeavour to use these organisations, not to obtain absolute mastery for one or the other, but to adjust differences on right lines. Settlements on wrong lines, effected either through power of money on the one hand or through the pressing of narrow sectional views on the other, can but dam up latent forces.

The engineering unions should frankly accept specialisation and adapt themselves to the changing circumstances; they should, I think, grade their membership from the highly-trained all-around mechanic to the machine tender who, owing to simplification of processes, cannot rank as an engineer but who is entitled to a guaranteed living wage. The employers on the other hand should frankly recognise the right of the unions to bargain collectively for their members.

This done, adjustments would, I believe, be simple enough and both sides might even find common ground for the use of their energies in freeing industry from unjust taxation and other vexatious conditions that now press upon it to the detriment of both.

The following sentence, taken from the preface to the rules of the Amalgamated Society of Engineers, fairly enough expresses the object of the trade unionist—new or old: "That we may leave to a future generation not only a trade, but the means of maintaining its best interests, until some more general principle of co-operation shall be acknowledged in society, guaranteeing to every man the full enjoyment of the produce of his labour." This was written fifty years ago and still stands as the best exposition in brief of the legitimate aim of the engineering operatives who are trade unionists.

INTENSIFIED PRODUCTION AND ITS INFLUENCE UPON THE WORKER.

By Milton P. Higgins.

INTENSITY is the present order of progress. Especially is this true in regard to mechanical and industrial progress. To this great modern force, this excessive effort for the highest efficiency of time and money, is due our modern system of intensified production. While the central motive of the system is greater output through the use of machinery and mechanical appliances, another element in the motive is the greatest possible improvement in kind and quality of every product, so that every producer aims with tremendous intensity to put upon the market an article *both better and cheaper.* The combination of these two factors, superiority and low price, produces a result marvellous in its effect upon the evolution of civilization. Better and cheaper; both these desiderata must be attained—neither quality alone can lead to the desired result.

In museums containing the choicest products of past ages may be seen things made with the sole object of superiority. The most skilful artizans have wrought a lifetime upon a sandal, a glove, a time-keeper, or some such useful thing, that might, if possible, excel all others, and have produced an article which was most exquisite in finish, but so costly that only kings and princes could possess one. But when the highest skill, the most scientific learning, and the most wonderful of modern machinery are combined and intensified, both poor and rich can be supplied with the best things. To produce the best and cheapest requires the highest degree of organization, the wisest selection of workmen and allotment of the work to him who is fittest for that particular grade of work by what we call "division of labor," in factory and shop, and "choice of specialities" in science and profes-

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Intensified production—the great correlative of organisation in increasing economy of manufacture—is probably regarded with more groundless dread than any other phase of the new industrial system. Broad-minded employers, as well as honest labour leaders, fear to find in it influences narrowing to the powers and to the life of the individual workman. To all these there is a revelation and strong assurance in the eloquent presentation of the truth of the case, as seen by one of America's most successful employers and foremost students of the labour problem.—THE EDITORS.

sional life. This great modern effort to improve and to surpass has increased the speeds of our locomotives, our spindles, and our sewing machines. All tools and all machines are called upon to work faster and to produce from ten to one hundred times more than a few years ago. This calls for new and wonderfully advanced standards of machine design and construction, new principles to be considered, new mechanical combinations and methods to be invented. It requires stronger joints, reduction of friction, and superior metal, hardened and toughened to the greatest degree, to withstand the shocks and pressures brought upon it by the new conditions.

The effect of this demand upon the inventive and the engineering forces is a new dispensation, a world of opportunity to the educated mechanic and engineer. Regarding the great blessing flowing to the favored class of engineers, there can be no doubt; and so glorious and limitless is this enticing field of action that it would be interesting and profitable to discuss it at length were it not the intention of this article to deal especially with the effects of intensified production upon the masses of workers engaged in making things useful. The scientists, engineers, managers, superintendents, and foremen of industrial works taken together are, in point of numbers, an insignificant fraction of the vast army concerned in production and useful accomplishment. Every workman and every operative is just as much a man, with a body to be fed and clothed, a mind to be developed in some direction, with tendencies upward or downward, with habits good or bad, with a wife and babies to be supported, loved, or neglected, as the president or any one of the board of directors. What are their chances in this system of intensity? What is the importance to them of a proper conception of their chances? It is in attempt to answer these questions that this article is submitted.

There is a general impression that this so-called machine age, which is responsible for our system of intensified production, is an age not helpful to the laborer, but, rather, is degrading and debasing him. One listens to pathetic and eloquent talk about the poor operative, whose life is made narrow, dark, and sordid because he sits all day long tending a machine. I recently listened to this view from a prominent and influential Englishman, a member of Parliament, and a bright, able gentleman. "Why," he said, "what hope have we for the race with such a factory system as England has? I see men whose whole life consists in sitting by a machine simply to watch it drop a piece of wire out of one tube and see it enter another tube. What opportunity has such a man in such a divided labor system

through all the long hours of the day? I go to his home, which I find in an endless row of dingy, brown, box-like houses, one of a hundred, all just alike in the matter of brown dinginess, crowded poverty, and filth; and in this man's mind all of his dark environment is the result of this system of manufacture."

So it is believed generally by a sympathetic, unthinking people that division of labor, automatic machinery, and piece work, constituting our system of production, is the cause of degradation, instead of a possible remedy for it. The condemnation of the system is not only untrue and unjust; it is very harmful. No greater mistake regarding the well-being of our working people can be made than this erroneous belief regarding our industrial system.

It is not denied that the sadness and lack of life and interest that constitutes the most depressing exhibition of human existence in low living is found in some shop and factory life in Europe and America. But the great mistake and the great harm come in ascribing the bad condition of life to the system. It exists in spite of the system, which has within itself an escape from the lower to a higher life.

The modern industrial system is far from perfect; it has injustice and hardships; but no other system, real or imaginary, has presented such practical and unlimited opportunities to the masses. In any other system of production only the skilful ones, the superior ones, can be given a fair chance. Now, as never before in all the history of the world, this great mass of unskilled workmen can have it. The best use that was ever thought possible for these poor masses by the ancients was to dress them in uniform and send them out in armies to be shot down or cut to pieces by the enemies of their rich rulers. To-day the masses have an opportunity of creating and acquiring. This is not a mean chance; it is a grand chance, and the best that God has provided up to this period of time.

What is this opportunity? First, opportunity and means for a decent existence. Second, a demand upon the individual for a little better thought and action. Third, opportunity to do and be a little better by personal effort. Fourth, relief from excessive muscular fatigue and unhealthful conditions. Fifth, better social advantages and conditions. Sixth, opportunity for culture and education.

Suppose a young man has no technical knowledge, no skill of hand; the modern system says: "Here is a so-called automatic machine. We want you to run this and be responsible for its performance." What is an automatic machine? It is one that carries within its conception and construction and in its productive functions

a storage battery of brains, so that it will probably go a little while when fed and tended by a thoughtless boy or a brainless man, who is set at it and started with instructions to do one only of the least things possible for him to do, if he will but think and will to do it. That storage battery of brains which is in the automatic machine soon runs low; without some bit of renewing of the brain force which was put into it, it soon ceases to be automatic, and without new thought it is a dead and worthless thing. It has never had the breath of life breathed into it. The poet and the preacher would have one believe, apparently, that it had brains, and that the poor fellow who is employed to see that the piece that fell from one tube entered the other tube properly, was brainless *because* the brains were in the machine; or if the fellow had any brains or thoughtfulness when put in charge of the monster, his brains must necessarily soon wither and die because there was nothing to keep them active. Oh, what a fallacy! And what great harm and injustice in such teaching! While it is a fact that persons nearly brainless may be found running automatic machines, the brains that the operative should have and which he ought to develop there are supplemented necessarily by the foreman or the inventor or the machinist. That is, automatic machinery and thoughtless and brainless operatives are sometimes found together; but, as some one has said, "because two things are found together it does not follow that one is the cause of the other."

The automatic machine, which is one element only in our system of intensified production, seems to be a provision by a kind Providence in the evolution of mankind for the poor fellow born without great ambition or capacity. It gives him a fair chance not only in the struggle for better life, but a fair chance for existence, even if he continue in his choice to look downward instead of upward—even if he stop his ears amidst a thousand voices crying about him in the myriads of groans and clatter of machinery: "Help us with your little thought, your little care, your little skill, your little love." When the storage battery of brains in the automatic machine runs low and weak, some part cries for a drop of oil to smooth its voice and cool its parched tongue; or because a screw or nut is loose, it kicks as frightened hoofs striking the dasher, threatening ruin and destruction; or it chokes with dust and smut. To all these cries of the machine the heedless operative, "the poor fellow who has no opportunity for the exercise of thought," as the preacher says, sits still and watches the machine all day long. He does not care to offer a drop of cool oil or to tighten the nut that would give quiet and peace to the destructive

kicking, or to brush away with a cloth the grime that brings stoppage and death. So the operative—"poor fellow," indeed, who thus flings away his chances—sits there and broods over the lack of opportunity that he has heard lying testimony about. The little dingy corner in which he sits all day long is one cloud of opportunity so thick about him that, were he alive to it, he could not breathe. He sits amid all the voices crying in his ear for helpful thought, simple, easy, growing thought, and does not choose life, but loses his soul.

The soul of a workman who loves his work grows all day long. How can a man love his work and lose his soul? A man that loves his work will love his wife and children, he will have a home, he will grow, grander opportunity will open before him and satisfaction and even happiness be his. If one loves his work and dwells upon it with careful thought and interest, he elevates himself and exalts his work. A man is seldom, if ever, degraded by his work, especially if it be mechanical work, or having to do with machines and tools. All machinery and all tools are most intimately related to evolution and suggest, more than anything else, the creative faculties of mankind.

Can a man be made to love his work? Yes, but he needs help sometimes and encouragement. Some men love their work naturally, as men love nature by force of their own natures. But more frequently men learn to love the fields, the woods, and animals because of the attractive teaching and preaching they listen to. Ruskin, by his charming manner, his skill and loving devotion as a teacher, taught eyes that were born blind to open and see a world filled with wondrous beauty. By such inspiration the heart learns to love, and the life grows. So our humbler workers who join the industrial ranks as operatives should not be led to look upon their lot with hopeless pity. Such doctrine is false. They should be taught the glad tidings of a glorious truth that comes in this new order of things. It is a gospel that says to every operator: "Come with us and learn to think —begin a career that is ever open at the top."

This is a system diametrically opposed to the British life, which was and is one of horizontal stratification. The American system is one of vertical circulation, and the force which suggests upward draft in all its functions and all its social and industrial life is the current of thought. Be it ever so faint, it is always upward. In this system let the poorest, the meanest of operatives think and act and help along the little lines running directly to himself, and all will soon recognize the upward draft and there will be vertical movement.

According to the idea of a modern writer, if you put ten boys into

the poorest factory in America and set them at the most commonplace work, in three days nine out of the ten will be asking the tenth boy where things are and what they shall do next. If you watch you will see that the tenth boy has been thinking a little, that he stops a little to arrange things after the bell strikes, that he gets in a little early and sees little changes to be made in the location of boxes, thoughtfully observes the oiler fix a hot-box, and gets a chance to hand him a wrench. That boy is all right. No one need say to him, "poor fellow, he runs one of those machines, he has nothing to think about." He finds enough to think about. The saddest fact about some workmen is that they will not choose to think, or, if they do think, it is about the wrong thing, about things that do not lead them to love their work.

The system we are considering always takes men of a lower order and places them under conditions new, different, and better than before. For example, wherever a machine operator is needed, a candidate is taken from a rank lower than a machine operator. In the rarest instances are workers taken from positions of higher grade and degraded to the simpler task of tending a machine. For illustration, go into the great factories producing wearing apparel. The sewing machine running at lightning speed is not operated by those who have before been skilful in needle-work. Go into a machine shop where the parts of high-grade machinery, such as screws, shafts, and wheels are produced by automatic milling machines, lathes and grinding machinery, and it will be found that the operators of these machines are never men who have been degraded from the ranks of skilful machinists. But the operator is a new species of workman, evolved and advanced from a lower class of skill or from a class that has heretofore had no opportunity to develop skill.

If we wish to develop a thinking people we must first make a working people. Through the cunning of the hand, the mind is called upon to act. Thus our factories, if properly organized, may be and generally will be, as is now sometimes true, incubators, and breeders of men of higher character and happier lives.

The operators of automatic machines, whose failure to grasp opportunities for lack of helpful teaching has been the cause of a condemnation of our industrial system, are persons who have never had an opportunity to exercise thoughtfulness at all. If they could be put in any position on earth where more thought and more responsibility were required, failure would surely follow; not only failure to get anything accomplished in the duties of the position, but failure to accomplish anything in the way of developing the individual; and

this is simply because too much is undertaken at first. The ideal condition for such human nature is a place very easy to enter at the bottom and open at the top for all advancement in activity of thought, but where the continuance of opportunity is not jeopardized or the individual disheartened, even if mental activity and general advancement are very slow or even reduced nearly to zero. It is at such a point that proper teaching and education are needed, and it is this grand opportunity which America should recognize.

Imagine a workman engaged on the most monotonous occupation that is talked about, where he has nothing at all to do but see that a piece falls out of one tube and enters another. There are really no such men employed. The field of duty is always broader than that, and the responsibility is generally as great as the individual can properly assume. But suppose there is such an extreme case as an operative engaged upon such a machine. Suppose then he is able and willing to do some profitable thinking, and instead of assuming that his chances are hopeless, let him be taught, let him see that this machine is one of the greatest accomplishments of the greatest faculty of mankind, *the creative power*. To secure the best results, and to evolve all that may be possible from this machine in its present condition, the operative must comprehend all its functions, its weaknesses and its possibilities, its temptations and its dangers. It is so made that it will go on very well for a while if he simply feed in the material and remove its product. Thus he is enabled to enter and be introduced to a great world of thought and action, and to be received cordially into this realm of mechanical industry without a technical training or much skill of hand. The conditions for entrance are very low, but his career is open at the top and his field of thought and self-improvement is unlimited. Let him see that there is infinite beauty in every mechanical movement and wonderful interest in every function, that its conception, comprehension, and perfection is the highest work of man, and that the shaping of a perfect screw-head or the production of a faultless pin-point is a thing of beauty and a source of enjoyment. Show him the infinite relation of his personal daily toil and duty to all the other great and beautiful things of the outer life of the universe. This is all possible so far as our industrial system is concerned. The capacity of the workman is our only limitation—and what other system can possibly reach down so low and so kindly? If this be true, how can we say that our system is degrading or oppressive upon the masses of workmen because each one must be a specialist and do his particular work better than any other? Add

to this other facts whereby his social relations and opportunities are immeasurably better than the working man has obtained since the beginning of history. His hours of labor are reduced already to a limit below almost any expectation. This is made possible only through intensified production, the system of machinery and division of labor, piece work, etc. By this the American workman has time for home, family, social enjoyment, and self improvement far beyond that of any other age or system; and better things are coming fast to him who waits and works patiently and actively in sympathy with the great all-powerful and inevitable system.

It still remains to show another line of benefit of even wider importance than any other, viz., the effect of the system upon the people's education.

Notwithstanding the just pride in American popular education which exists in the United States, the fact still remains that all education, except the most elementary grades, affects only the few, say one in one hundred. The ninety and nine unaffected by higher education are our people, and they constitute our great national force and power. America is not likely to suffer when its engineers are compared with those of any other nation. American universities have now arrived at a stage that renders it unnecessary for us to send our sons away for the best training in science and engineering. But our technical schools are year by year devoted more and more to the education of the scientist and the professional engineer, while the field, no less important, for the technical training of our skilled workmen, is still left as uncultivated as ever. The best and fittest education of our working people is of the highest importance, and the neglect of it the greatest danger to the supremacy of American industry. Trades schools, skill teaching, is the one great opportunity America should realize and grasp.

Our industrial system tends directly to give more time and leisure hours for education of the workers. It so emancipates the worker from excessive fatigue of both mind and body that the first condition of education is met. This system not only opens the way to the attainment of technical knowledge through time for thought and study, but opens the way to a culture which is, in fact, more than half of the benefit of what is termed a liberal education.

Culture is the one thing above all others that the American mechanic needs to exalt his most noble calling and advance his standing among men. Culture, rather than learning, is that which sets the university man on high. It comes largely through contact with better

men and with good men of all grades. The intense industrial system brings every grade of worker into respectable contact with his superiors, and he associates with all grades of men.

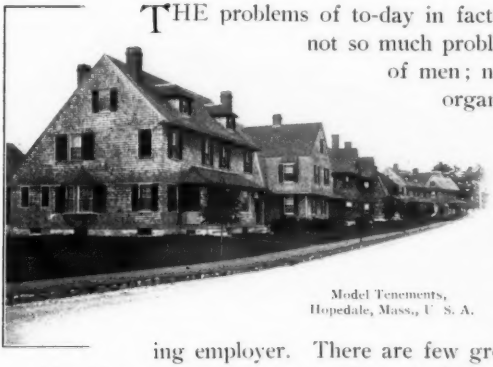
We read much that is said of the benefits lost when the old apprenticeship system passed away. We must remember that, though the apprentice enjoyed a home-life with the one master, it was, nevertheless, a narrow life, and a life confined to rigid limits. Now, the mechanic who enters the ranks at the lowest or simplest stage, that of a machine tender, is immediately brought into contact with a master who is selected for his ability and superiority as a workman and as a director. In the true sense the humblest worker is now an apprentice to trades broader and more varied than ever before. He associates and competes with many co-workers; he is usually well treated and favorably considered by all the force of better educated men.

The benefits of this system can hardy be overstated. Contact with others and with superiors is the main source of culture, and when the American mechanic adds culture to his skill and technical training, he will stand among the favored ones of earth, and his influence will be broad, good, and mighty among men.

We have been blinded and confused in our faith and confidence in a great and emancipatory principle, which underlies and involves this system of intense production, because of some previous evils which have existed in spite of all the good that is likely to flow from the very system which is falsely condemned as the cause of the supposed evils. The system does not produce the evils which some trade unionists think. The system has within it the elimination of the evils. And this elimination will soon take place if proprietors and workers of all grades join in the inevitable recognition that the system is the new dispensation which makes for the greatest good to all workers, elevating each and everyone according to his personal and individual merit. The great industrial redemption is sure to come through this very system. The greatest hindrance comes from the false belief that there is an element in the system tending to crush and oppress the humbler worker, and that systemized and concentrated industrial factories, with automatic machines and tools, with just systems of piece work and of division of labor, etc., are in any way opposed to the betterment of every worker. It is unjust, unfair, and unnecessary to attempt to put all workers upon a dead level by dragging the better down. Instead we should hold to all that is high and good, and reach out a hand to bring up the lower.

ALTRUISM AND SYMPATHY AS FACTORS IN WORKS ADMINISTRATION.

By John H. Patterson.



Model Tenements, Hopedale, Mass., U. S. A.

THE problems of to-day in factory management are not so much problems of machinery as of men; not so much those of organization as of personal relations. How best to develop the principles which are necessary for the solutions of these problems is the question with every thinking employer. There are few great companies in the world with organizations as complete or plants as well equipped as those of the great manufacturing establishments of the United States, and American manufacturers are anxious to retain their position of priority in the world. The one problem whose solution will assure permanence in the new commercial life of the nation is the adjustment of relations between employer and employee on a fair and humane basis. If American manufacturers and their workmen unite in enthusiastic development of one another's interests, they will retain their leadership.

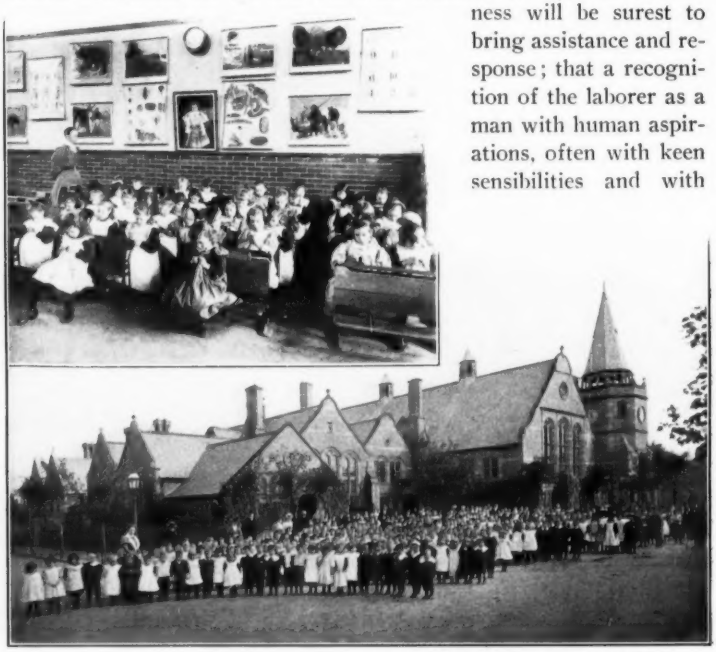
The introduction of steam power into the manufacturing world drove the little blacksmith shop, shoe shop, the country dairy and weaver's loom, from the village into the city and opened many new problems. In those early days, the small workman found it best to consider carefully the physical, moral, and mental welfare of his apprentice and his assistant. If it paid the small employer to do this, it

A tour of the machine shops of the United States and the newer works of Europe gives few impressions more striking than the one created by the widespread evidence of growing thought for the comfort of the workman. Humanitarian considerations aside, *it pays*—pays in quality and in lowered cost of output—when the worker is kept well nourished and in good hygienic surroundings. It is not, of course, possible for all works to go so far as some of Mr. Patterson's examples indicate, but the general principles are everywhere applicable and for this reason the many actual instances shown are of universal value.—THE EDITORS.

will pay the great employer many-fold more to have the same thoughtfulness for the hundreds or thousands in his employ.

The difficulty will be to determine what is needed for this adjustment, and how to accomplish the arrangement even with the needs recognized. It would seem, however, that all will agree that among the essentials to economic production and a proper adjustment of relations are opportunity for thorough training of the workman, and his co-operation in saving and in perfect manufacture.

Some employers have sought to win this sympathy and assistance by large gifts to libraries, museums, and other public institutions open to working men. Others have aimed at it by a system of profit sharing, and still others, in increasing numbers, have sought it by introducing special features into their factories and by opening unusual opportunities to their people. This latter plan has as its foundation principles the ideas that an evidence of daily thoughtfulness will be surest to bring assistance and response; that a recognition of the laborer as a man with human aspirations, often with keen sensibilities and with



FEATURES OF THE ALTRUISTIC POLICY OF WORKS MANAGEMENT BY LEVER BROS., AT PORT SUNLIGHT, ENGLAND.

Village schools and school children. The interior of a class-room is seen in the upper corner illustration.

VILLAGE BOWLING GREEN AND MEN'S SOCIAL CLUB, PORT SUNLIGHT.

THE GIRLS' INSTITUTE, PORT SUNLIGHT

love of home and comfort, will find a responsive chord within; and that poverty, lack of education, and narrow views are not necessarily evidence of a lower form of life.

It is with this in mind that a large number of employers are seeking to adapt their factories and methods to the needs of to-day. The personal experience of the writer and of others who are seeking by similar methods the same results, may not be out of place in this magazine. These are given as illustrations of what may be accomplished, and how it may be done, rather than as statements of relations to be closely followed. Thoughtful men to-day want not so much theories as facts. Hence, experience and actual work of the shop will be more acceptable than a discussion of what ought to be done.

It is difficult to understand why so much carelessness exists regarding the condition and ventilation of the average shop. The very first essential to the solution of the humane elements in the machine-shop problem is clean and well-ventilated buildings. It is often assumed that this is possible only for certain forms of light and clean manu-

facturing, but experience has proved that even in heavy machine shops, rolling mills, woolen mills, and paper mills, cleanliness and good ventilation are possible. The expense of accomplishing this is so small as compared with the increased output resulting from it, that one wonders that any company ever hesitates to accomplish these things. It does not require much force or a great expenditure of money to have clean floors and windows and to furnish fresh air. In addition to this, good drinking water, comfortable toilet rooms, and proper heating, will assure health and, therefore, better work. The National Cash Register Company's experience in this matter is constant proof of the value of bright and cheerful surroundings as well as of perfect cleanliness. Its buildings six years ago were completely remodeled and renovated, and from that time to this cleanliness, good ventilation and proper heating, have been emphasized with remark-

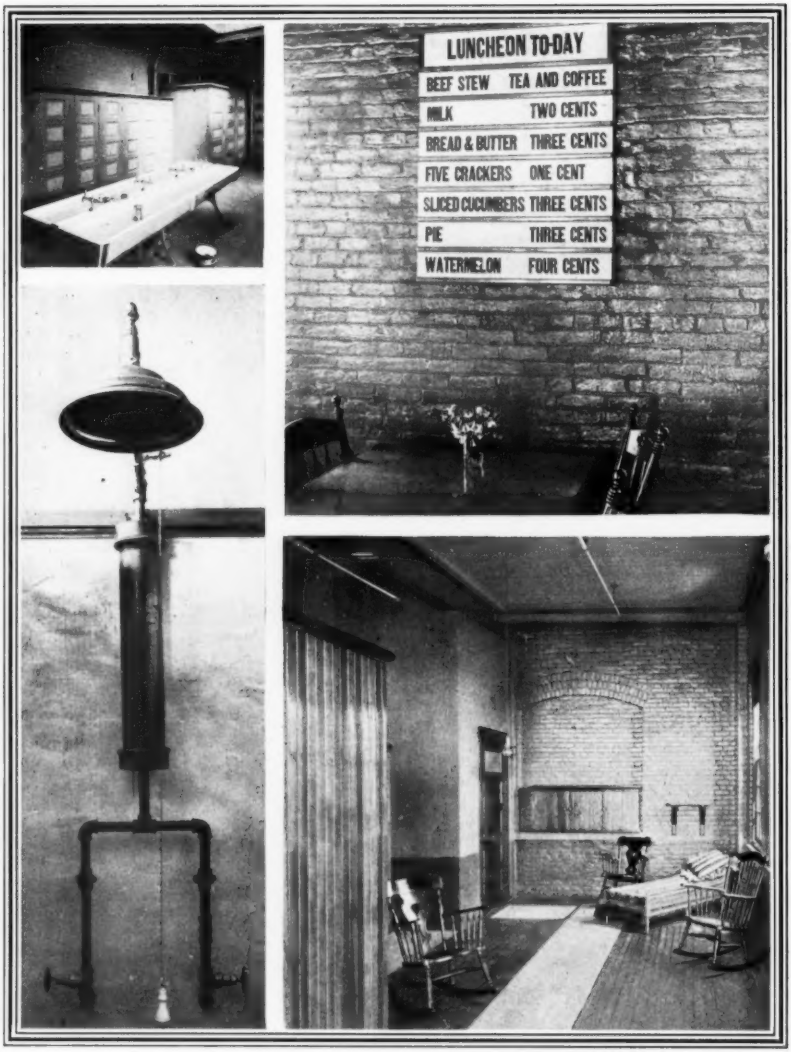
DINING ROOM FOR EMPLOYEES, CLEVELAND HARDWARE COMPANY'S WORKS.

able success. The Sherwin-Williams Co., of Cleveland, in its paint mill, and the Cleveland Hardware Co., in their rolling mill, have shown what can be done when proper inclination exists. In England are a number of very notable examples of the value of beautifying factory grounds and employees' cottages. The most prominent of these are the Lever Bros.' soap works, at Port Sunlight, and the Cadbury cocoa works, at Bourneville.

Attention to personal comfort is another of the essentials in the

SOME SPECIAL INSTITUTIONS OF THE CLEVELAND HARDWARE COMPANY, CLEVELAND, OHIO, U. S. A.

The lower picture shows workmen lining up for the lunch furnished at trifling cost. The upper ones illustrate the girls' rest room and the library.



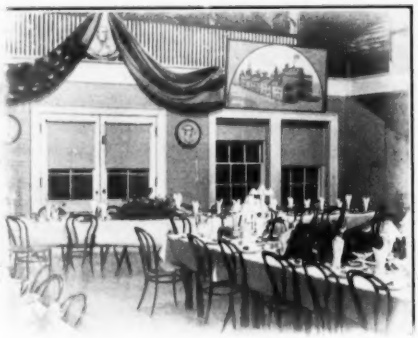
PROVISIONS FOR WORKMEN'S COMFORT AND HEALTH MADE BY THE SHERWIN-WILLIAMS COMPANY, CLEVELAND, OHIO, U. S. A.

On the left are seen the lavatory arrangements—the upper picture shows also the men's lockers. The lower picture on the right illustrates one of the rest rooms; in the cut above is shown a lunch bill of fare, changed daily.

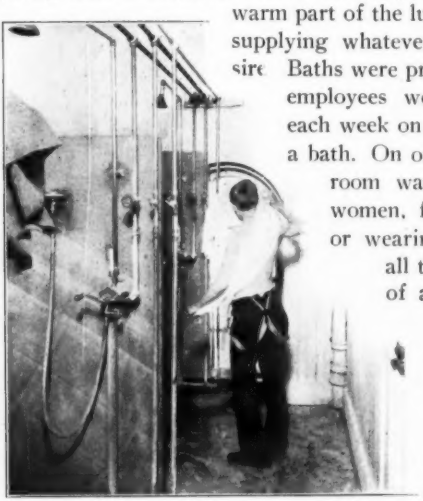
TWO LUNCH ROOMS, THE SHERWIN-WILLIAMS CO , CLEVELAND, OHIO, U. S. A.

The employee's own lunch is supplemented by hot dishes, tea, coffee, etc., served at exact cost, with no charge for service. Reading and recreation facilities, washrooms, laundry, etc., are also provided.

recognition of the needs of employees. By this is meant thoughtfulness for comfort in work—proper arrangement for lunches and food—opportunities for rest, for baths, and for all those things which add strength and encourage contentment. When our company began its present system, it first provided stools with backs and foot rests for its employees. Then arrangements were made for the women of the factory to ride up and down on the elevators, if they chose, instead of climbing the stairways. Ten-minute recesses were given to the women in the morning and afternoon, affording them opportunity for relaxation. A large dining room was provided, in which a wholesome lunch is served each day at noon to two hundred and fifty or more of the young women employees of the company, the company furnishing the warm part of the lunch, and the young women supplying whatever additional they may desire. Baths were provided in all buildings, and employees were given twenty minutes each week on the company's time to take a bath. On one of the floors, a neat rest room was provided for the young women, for use in case of sickness or weariness. Cots are supplied in all the buildings for use in case of accident. Other companies have carried out many of these same ideas, some by fitting up rooms in their own factory buildings—as in the case of the T. B. Laycock Mfg. Co., of Indianapolis, and the Acme White Lead Co., of De-



THE GORHAM CASINO. MAIN DINING HALL SET FOR A BANQUET TO THE HEADS OF DEPARTMENTS.



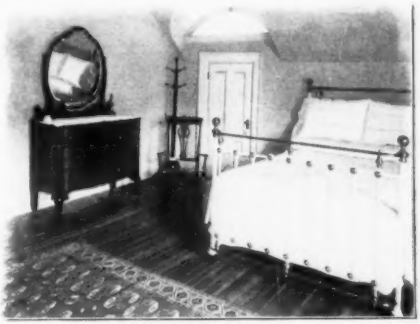
MEN'S BATH ROOM, NATIONAL CASH REGISTER CO.

YOUNG WOMEN'S LUNCH AND REST ROOM, T. B LAYCOCK MFG CO., INDIANAPOLIS, IND., U. S. A.

Coffee, tea, cream, and sugar are supplied at the expense of the company. After lunch the employees may spend the time reading or playing the piano.

troit—while others have provided and equipped club houses adjacent to the factory with the conveniences of lunches, baths, and reading rooms, open freely to all employees. The Gorham Manufacturing Company, the Joliet Steel Works, and the Eagle & Phœnix Company are illustrations of this idea in the treatment of employees.

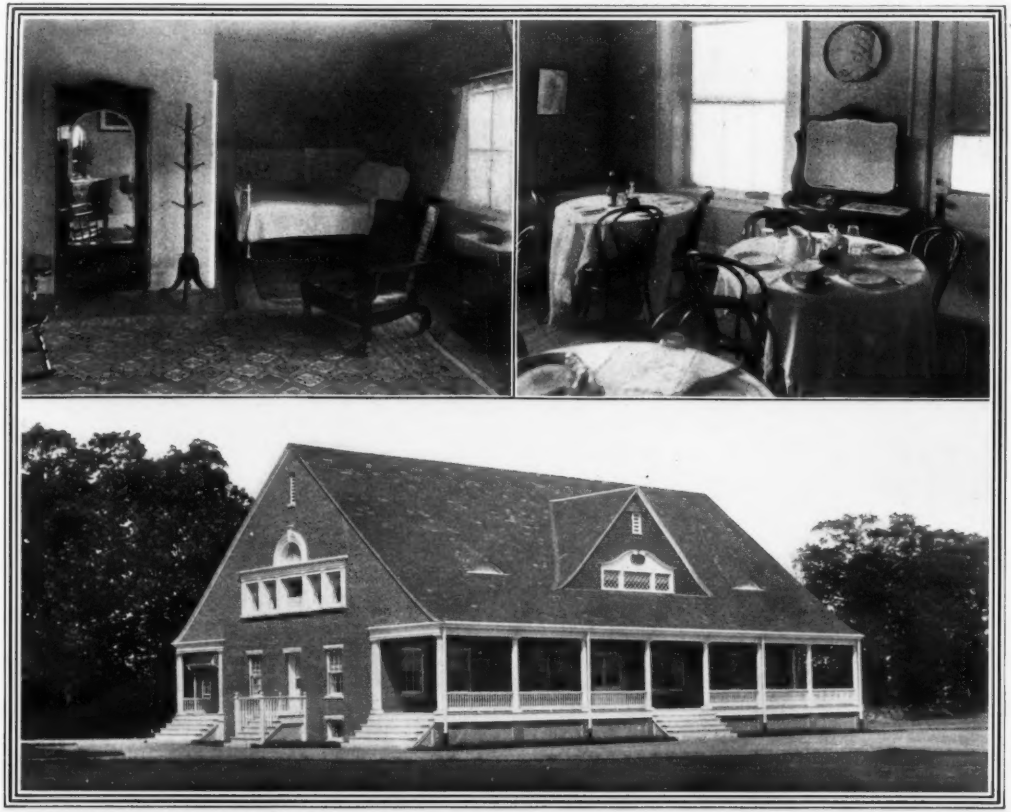
It is not sufficient, however, to think simply of the physical wants. To accomplish one of the great aims of all such plans—that of securing intelligent operatives—it is necessary to afford the work people opportunities for mental training and mental growth. This idea when first advanced was combated in many cases, but employers generally are now agreed that skill and intelligence are essential to the highest accomplishment. Our first



THE GORHAM COMPANY'S CASINO. A BEDROOM.

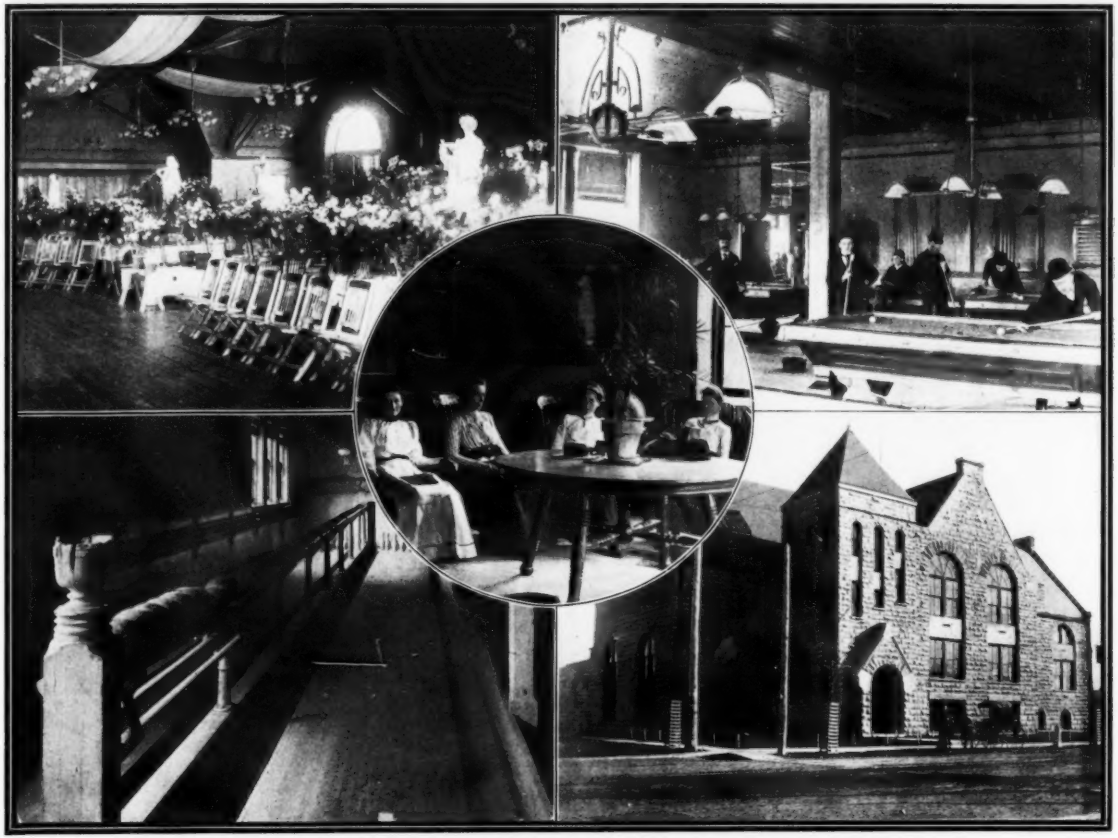
CHARACTERISTIC INSTITUTIONS OF THE ACME WHITE LEAD WORKS, DETROIT, MICH., U. S A.

A.—A lecture on the Chemistry of Paints. B.—Preparing coffee for employees. C.—Lunch for the office force.



THE CASINO OF THE GORHAM COMPANY, PROVIDENCE, R. I., U. S. A., WOMEN'S DINING ROOM AND A SLEEPING ROOM.

The efforts of the company to advance the comfort, education, and recreation of the workmen centre in this institution. The main object is to enable the men to enjoy their midday meal. The main dining hall is used also for concerts and social entertainments. On one side of it is a library and reading room, and on the other a private dining room and a women's dining room. In winter the ample piazzas are enclosed by glass sash.



FEATURES OF LABOR MANAGEMENT AT THE JOLIET STEEL WORKS, JOLIET, ILL., U. S. A.

The characteristic institution is the Steel Works Club, which comprehends many social, educational, recreative, and benevolent features. The club house is shown in the lower right hand corner. Above is the billiard room. On the left are the auditorium, taken during a flower show, and the bowling alley. The center view shows a woman's club meeting.

step in carrying out this idea was to give the fullest information to everyone regarding the company's work and business. This was accomplished by frequent meetings of a part or all of the employees, by conventions, by publications, and by announcements. A club consisting of the heads of departments and their assistants was formed, meeting frequently on the company's time in a large hall of the main building, provided for the purpose, with the object of discussing important topics relating to the general business and of receiving suggestions and complaints from the departments. Realizing that many of the employees

MAIN DINING ROOM IN THE GORHAM CASINO.

The men are invited to bring their own lunches, and can add tea, coffee, milk, etc., supplied by the company at absolute cost.

needed instruction in simple mechanics, general meetings were held, where, by special entertainments, made interesting by the use of stereopticon pictures, instruction was given in the simplest elements of mathematics and mechanics. By these methods the company succeeded in proving to its employees that its motives were for their highest good and, step by step, their attitude changed from one of indifference and opposition to one of enthusiastic support. Other companies, like the John B. Stetson Company, of Philadelphia, have found these

same ideas practical and have carried them out, adapting them to their own particular needs. The Cleveland Window Glass Company, the Acme White Lead & Color Works, and other companies have well-organized classes for instruction in special subjects.

THE BAND. AN EMPLOYEES' ORGANIZATION IN THE JOLIET STEEL WORKS.

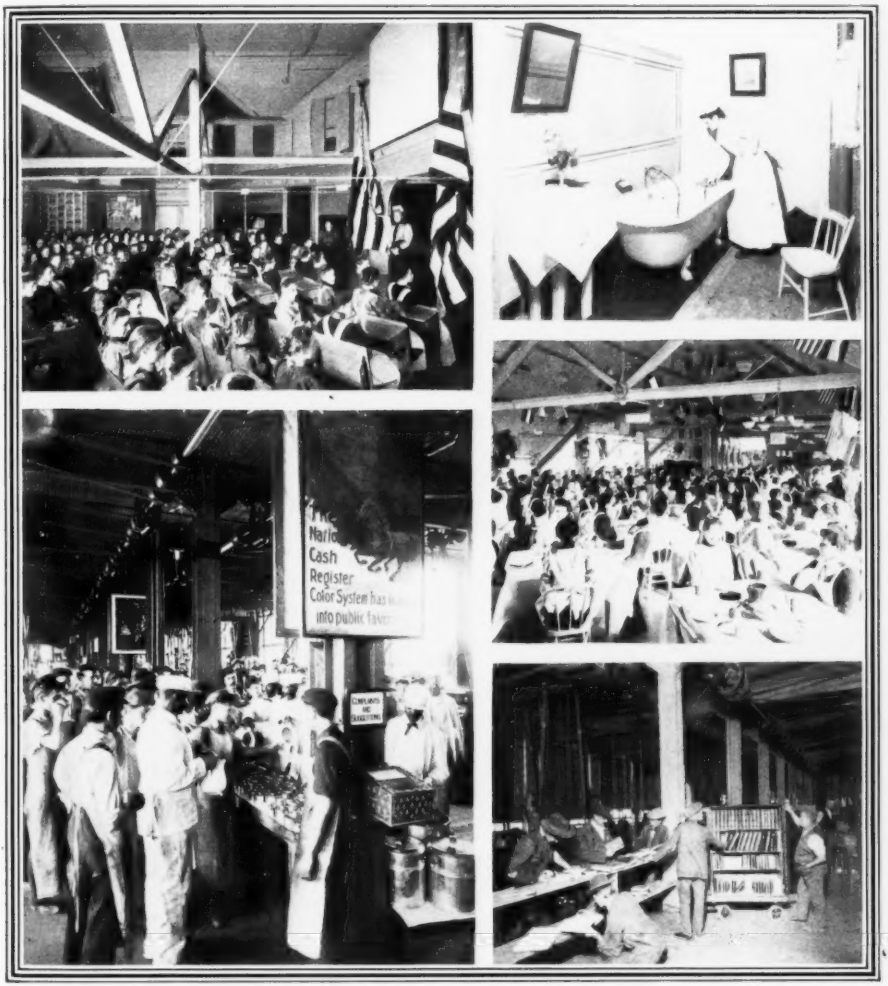
One of the most thoughtful methods in the development of sympathy has been the system of prizes for suggestions, which has resulted in leading everyone to seek to assist and to give his best thought. This is accomplished usually by placing in the various departments an autographic register or a small box, upon which one may write his suggestion, or in which he may place the idea or complaint which he desires to present. Each man and woman is encouraged to think independently, and to watch for improvement in his own work and that of others. Series of prizes are offered, ranging usually from $10 to $50 each, covering a period varying in different companies from one month to six months. These prizes are usually open to all except heads of departments and assistants. As suggestions are received, they are carefully examined by one appointed for this purpose and when practicable, are put to good use and proper credit given. The

HUMANITARIAN FEATURES OF THE LABOR POLICY OF THE JOHN B. STETSON COMPANY, PHILADELPHIA, PA., U. S. A.
The Assembly Hall, Dispensary, and Hospital.

occasion of the presentation in most of these factories is one of great interest and enthusiasm. In the practice of our own establishment it is always made an opportunity for bringing together the employees and their families. During the summer it becomes an out-of-doors gathering, at which thousands of employees and their families gather for pleasure and profit. This cultivates an *esprit de corps* which is felt throughout the entire factory. This company receives about 2,500 suggestions a year, a large portion of which may be put into actual practice. This same idea is becoming very popular among employers, the experience of the Eastman Kodak Company, Bausch & Lomb, and others proving in the highest degree satisfactory.

AT THE NATIONAL CASH REGISTER WORKS.
Prize trip of foundrymen to Cincinnati, and prize distribution at one of the annual festal occasions.

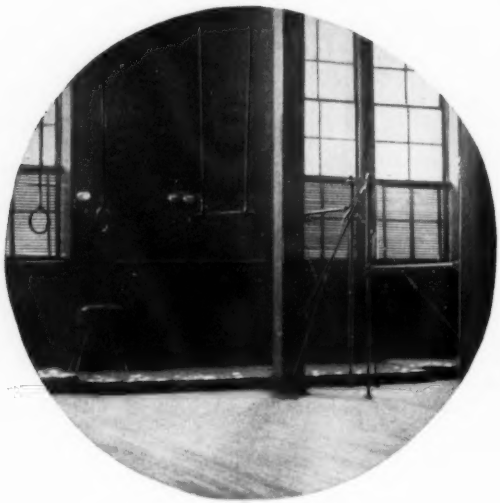
This encouragement to think for the interests of the company finds its expression very frequently on the part of employees in organization of clubs among the workers themselves. In this company, there are the Women's Century Club and the Men's Progress Club, meeting twice each month, with regular programs and carefully-wrought schemes of work. Relief-association organizations, for systematic assistance in case of sickness, are popular in many companies. Organizations for recreation or study are sure to be formed when a community feeling has been carefully developed among employees.



VIEWS ILLUSTRATIVE OF THE ALTRUISTIC POLICY AS CARRIED OUT BY THE NATIONAL CASH REGISTER CO., DAYTON, OHIO, U. S. A.

Below on the left is a photograph taken while lunch was being served to men obliged to work overtime; above is the assembly hall during an address to the women employees' Century Club; on the right are three engravings showing the lavatory, lunch room, and circulating library.

To assist in thus cultivating thoughtfulness, a factory library and reading room are valuable. It has been found that city libraries are always ready to co-operate in the development of this idea to the full extent of their ability. Stereopticon lectures, on all questions which will lead men to think, are very helpful and popular. It adds some-

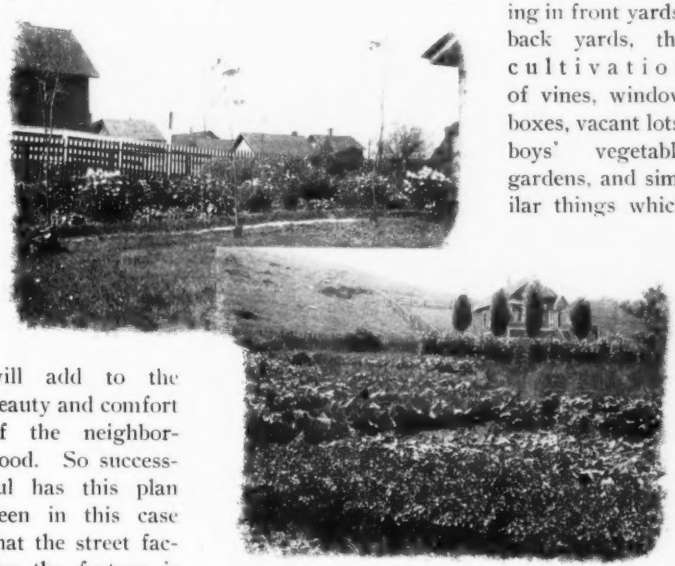


JOLIET STEEL WORKS. THE GYMNASIUM

thing to the intelligent work of the employee to know something of the country into which his product is to go. Therefore, practical talks on England, Germany, and other countries of the world, all assist in leading to thoughtful action in connection with the work. Quotations from good literature and suggestions on practical subjects, hanging in various places in the factory, all increase this thoughtfulness of the employee.

The duty of the employer in this problem is not completely fulfilled if he confines his efforts solely to his employees. Too often, the coming of a factory into a neighborhood is considered a misfortune, and has a depressing influence upon the value of residence property within its vicinity. This is not necessary and, with a little effort on the part of the factory people, it may be avoided. The factory may be made a center of life and influence for the entire neighborhood. A club house or settlement house immediately adjoining the factory premises, with

qualified men or women in charge, will rapidly become a center of social, educational, and moral influence for the entire community. The "N. C. R. House" at Dayton is a little cottage in charge of a deaconess who gives her entire time to the needs of the community, and contains a library and reading room open to the neighborhood, a kindergarten for the children of employees and the neighborhood, and a room for the meetings of numerous clubs organized among the boys, girls, young people, and men and women of South Park. In addition to this, prizes are offered amounting to $300 a year, for the improvements in homes, yards, and surroundings. This includes planting in front yards, back yards, the cultivation of vines, window boxes, vacant lots, boys' vegetable gardens, and similar things which will add to the beauty and comfort of the neighborhood. So successful has this plan been in this case that the street facing the factory is regarded as one of the most beautiful working-men's streets in the world. The company in this case has set an example by beautifying its own grounds and surroundings in every way possible, seeking to accomplish the desired result by following the simple rules of good landscape gardening, and by the use of such shrubs only as the people themselves may cultivate if they desire. This idea is not wholly confined to this one company, though it has not been followed very extensively in the United States, outside of some of the older New

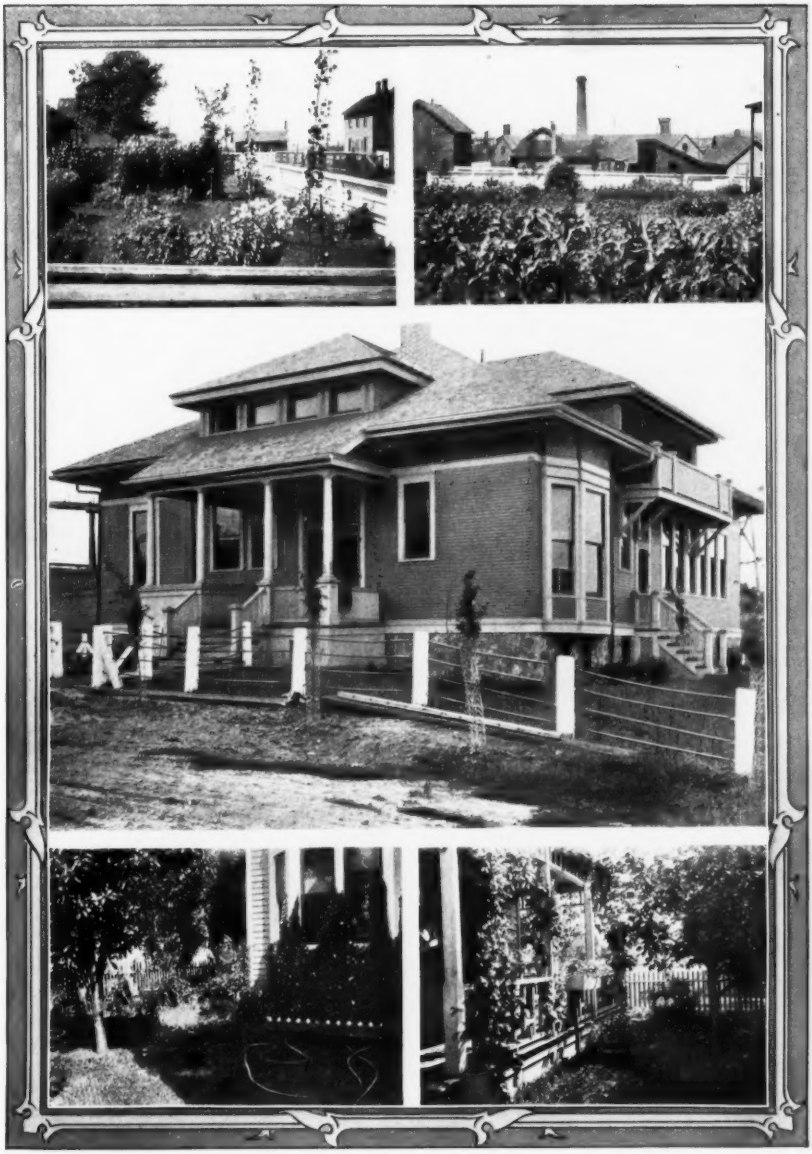


PRIZE GARDENS, EMPLOYEES OF CLEVELAND CLIFFS IRON CO., ISHPEMING, MICH., U. S. A.

FACTORY EMBELLISHMENT. A CORNER IN THE CADBURY WORKS, BOURNEVILLE, ENGLAND.

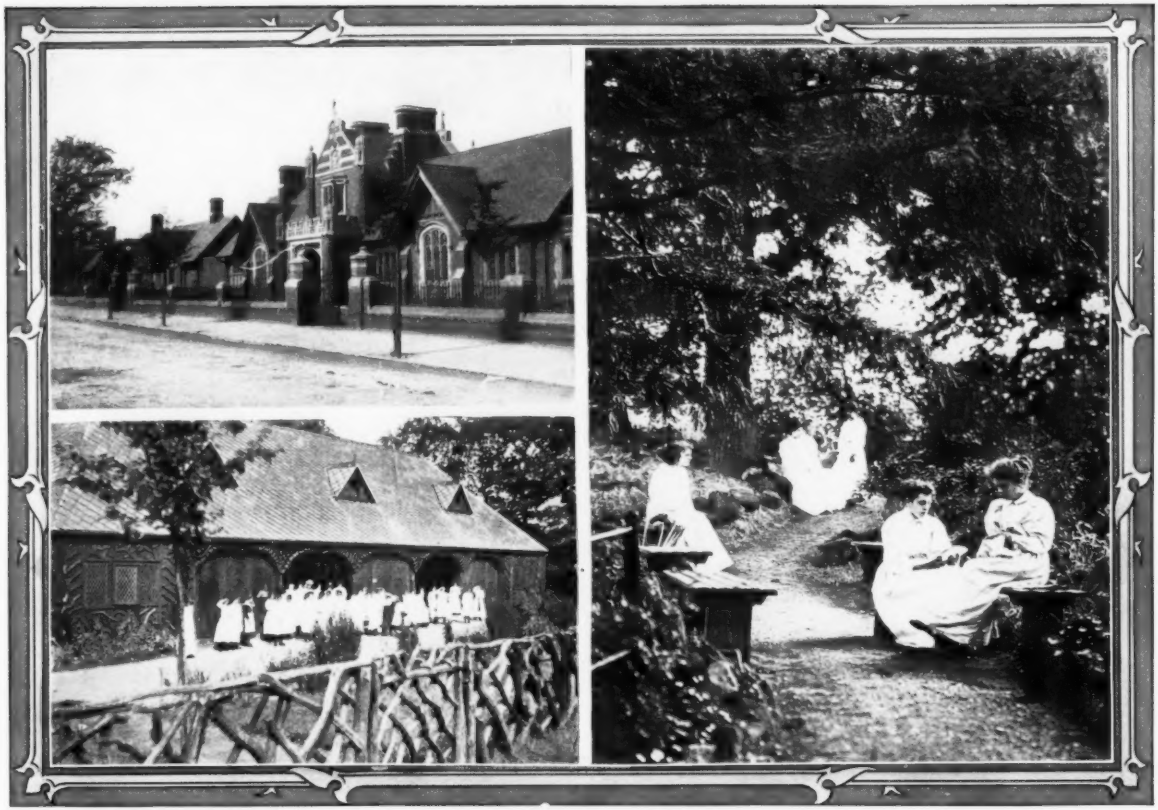
England factory towns. The most prominent examples, perhaps, are in England, including those of the Lever Brothers' Company, of Port Sunlight, and Cadbury Brothers, at Bourneville. The Draper Company, at Hopedale, Mass., and the Cleveland Cliffs Iron Company, at

THE VILLAGE POST OFFICE, PORT SUNLIGHT



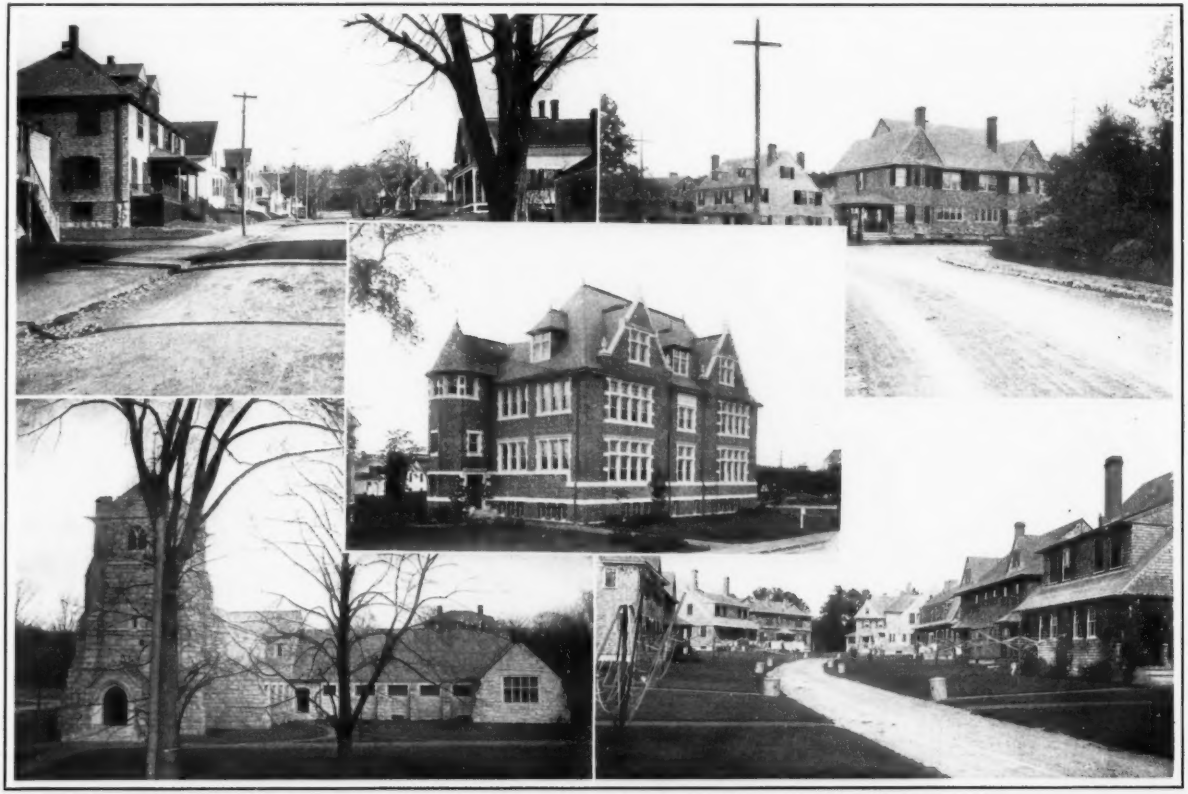
CLEVELAND CLIFFS IRON COMPANY, ISHPEMING, MICH., U. S. A. GENERAL OFFICE AND WORKMEN'S GARDENS.

The company stimulates neatness and thrift by offering prizes for the best-kept grounds and gardens. The illustrations are taken from the prize-winning homes of 1899.



AT THE CADBURY COMPANY'S WORKS, BOURNEVILLE. AGENCIES FOR THE CARE OF OLD AND YOUNG.

On the left are the almshouses and the pavilion on the girls' recreation ground. On the right are girl employees resting after the day's work.



CHARACTERISTIC FEATURES OF THE LABOR POLICY OF THE DRAPER COMPANY, HOPEDALE, MASS., U. S. A.

The town is built up in connection with the works. In the center of the group above is the grammar school; in the lower left corner is the memorial church. The remaining three views show portions of the model settlement of tenement houses which forms an important part of the company's system.

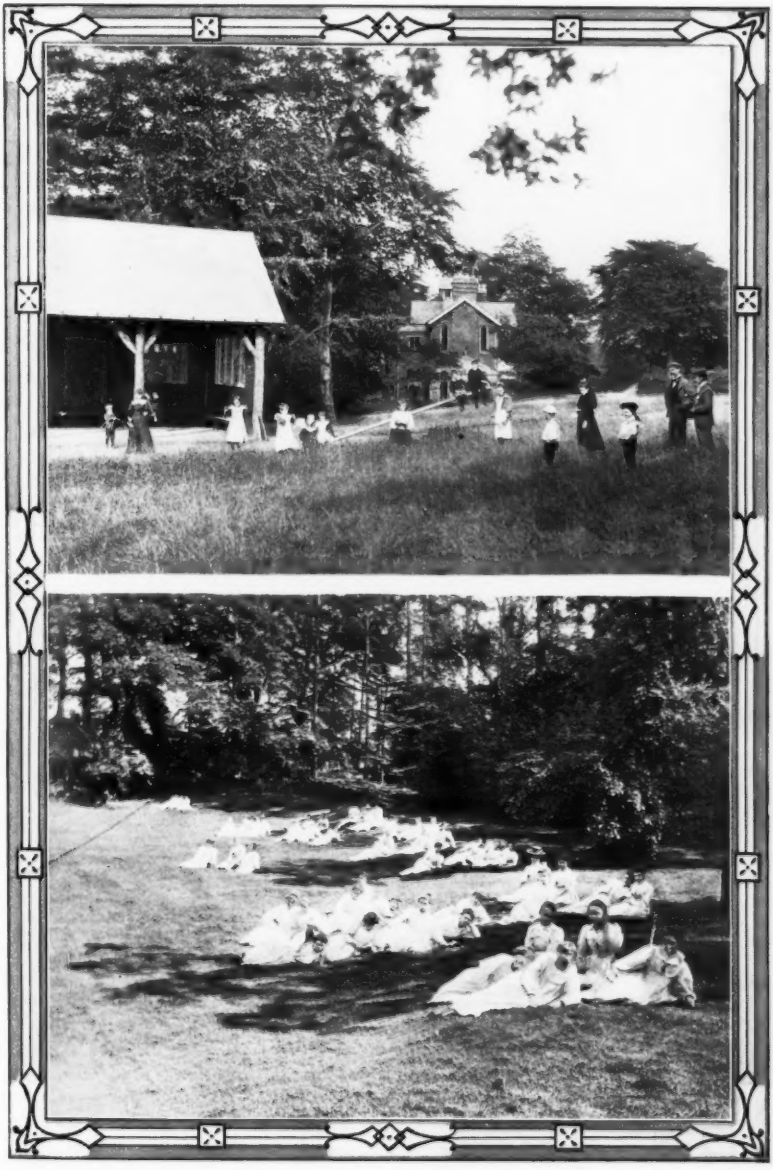
Ishpeming, Mich., are further illustrations of this idea of neighborhood improvement and the use of prizes for good planting.

THE MEMORIAL TOWN HALL, HOPEDALE, MASS.

Mr. Law's Briar Cliff farms, in New York, are an illustration of what may be done toward helping workmen in their lives. His idea of kindness to men and animals is expressed in the mural declarations in the homes which he has erected on these farms for his unmarried employees:

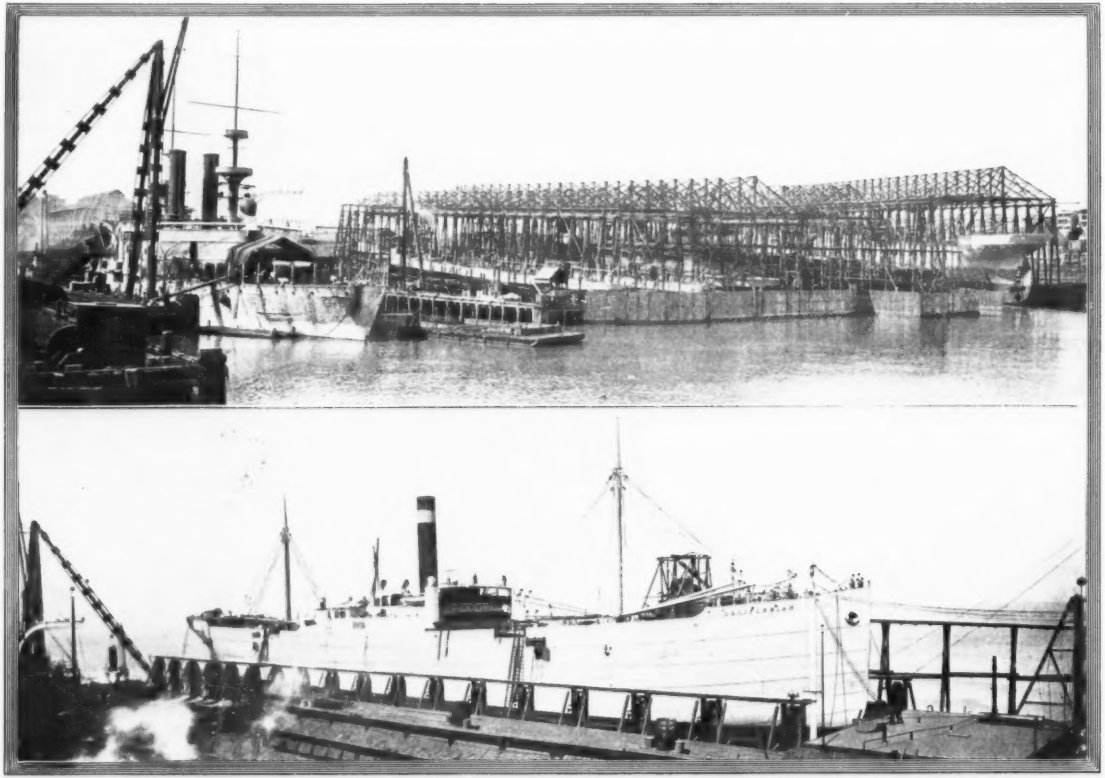
"Speak gently—it is better far
To rule by love than fear."

Going one step further in the recognition of this responsibility toward the neighborhood is the establishment of kindergartens, manual training schools, "pleasant Sunday afternoons," and other organizations under the encouragement of the company and its officers. This company has, for a number of years, supported a kindergarten open to the children of employees and of the neighborhood. It has a domestic-economy department, with cooking and sewing lessons for the girls of South Park and the young women of the factory. It has a boys' brigade and various boys' clubs for the lads, who are enthusiastic in their co-operation in all the plans that are made and who, with increasing care, assist in keeping the grounds of the neighborhood in a beautiful condition. A penny provident association offers opportunity for saving. A women's guild enlists the mothers for the best interests to their homes and their children. A choral society attracts the young people, while the "pleasant Sunday afternoon," or "Sunday school," as it is often called, furnishes an hour or an hour and a half of helpful interest each Sunday afternoon. This is intended not for teaching religious truth so much as for giving practical instruction in the true ideas of moral life. Two features of this plan will always give good results. One is the encouragement of the reading of the children by offering prizes to those who read and bring quotations from their reading each Sunday. The other is the use of the stereopticon for one-half hour at each gathering, with lessons in practical things that will be a help in the home life.



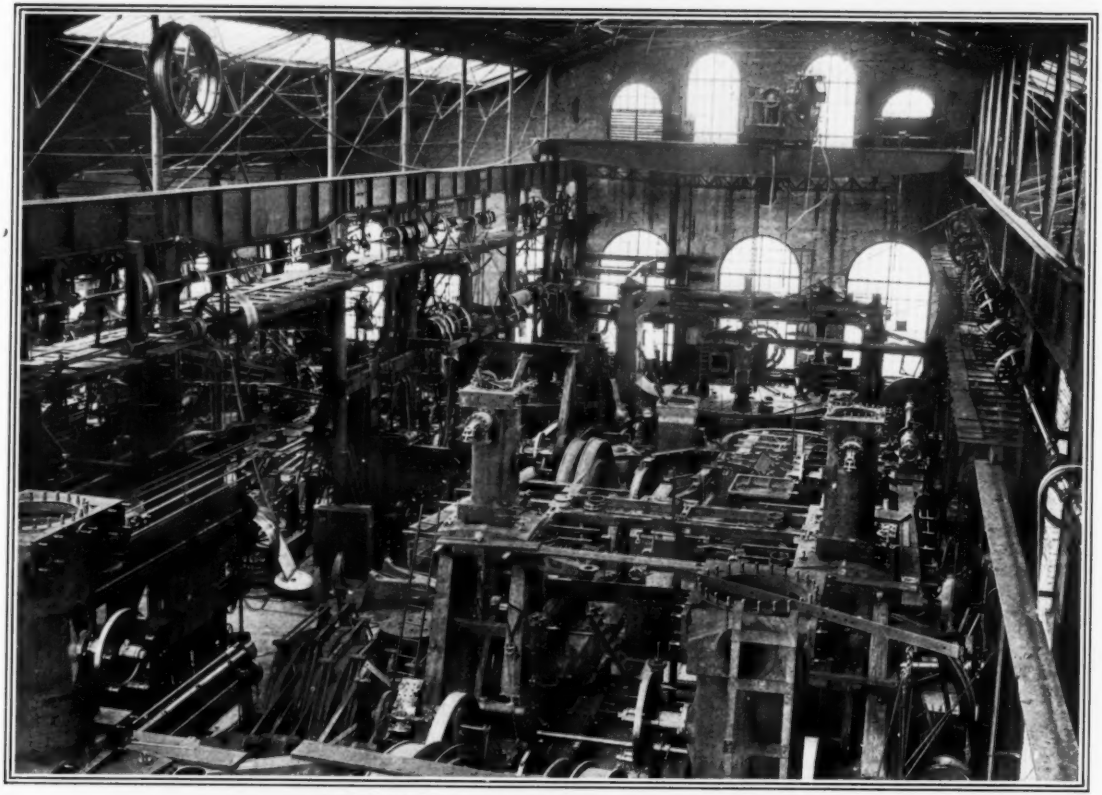
CHILDREN'S PLAYGROUND AND NOONDAY RESTING PLACE FOR EMPLOYEES,
CADBURY WORKS, BOURNEVILLE, ENGLAND.

Such, in brief, is a suggestion for practical methods of influencing the assisting employees and the neighborhood, and thus solving the personal problem of modern manufacturing. The suggestions here made have not covered all that may be done, but are those which have been found practical helps in one or more factories of the United States. These efforts have been recognized as helpful not only by employees, but by the leaders of labor, religious, and social organizations. The kindly spirit which they indicate is reciprocated, both at home and abroad. The plan has been studied by prominent men and women and commended by students in many lands. The opinions of public men who have studied these efforts encourage their continuance as being the surest method of solving this problem. Carefully-compiled statistics show that they will help to reduce the cost of production, and the system indicates a growing improvement in the character of the working people and in the increasing advantages, both to the company and to its force. Because these things require little change from the usual methods, they are practicable under existing conditions, and because of their broad helpfulness, they must prove valuable to all classes of the community.

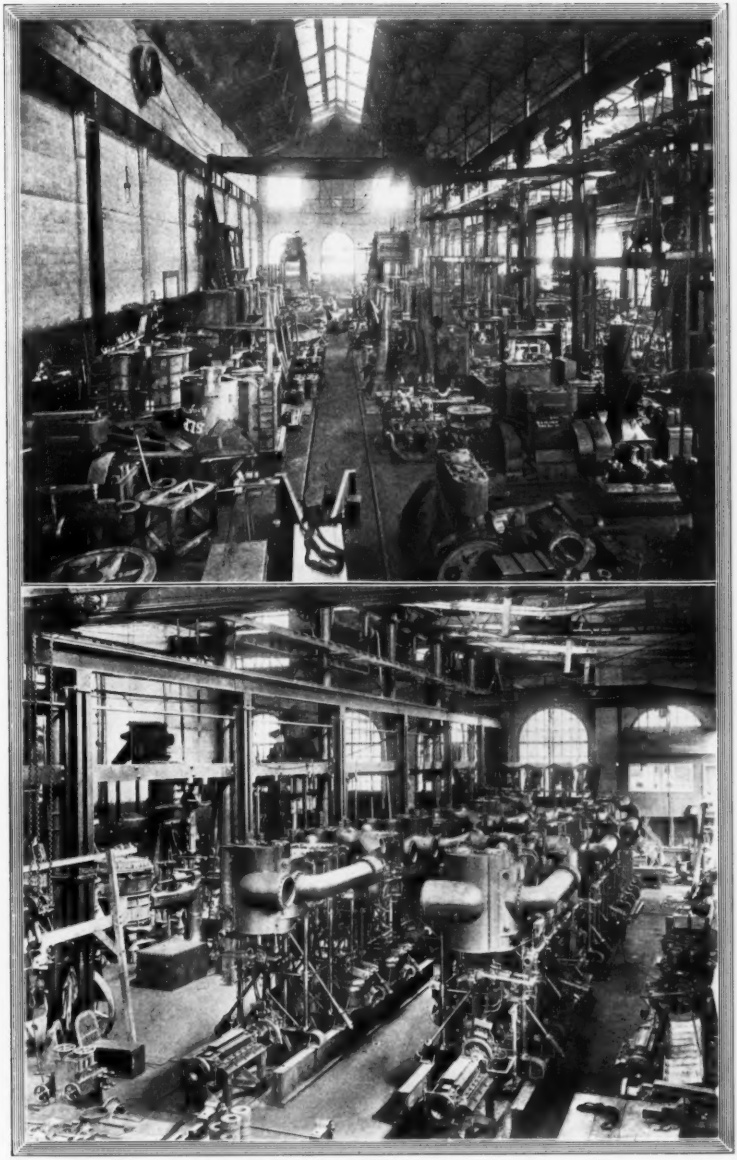


VIEWS IN THE UNION IRON WORKS, SAN FRANCISCO, CAL., U. S. A. THE BUILDERS OF THE U. S. S. OREGON.

The upper view shows the general water front. In the distance are the boiler shops; in front of them the U. S. S. Wisconsin at the 100-ton shear legs. On the stocks are the torpedo boats Paul Jones, Perry, and Preble, the monitor Wyoming, battle-ship Ohio, and freight steamer Californian, 8,000 tons' cargo capacity. Below is the hydraulic dry-dock with a vessel lifted upon it.



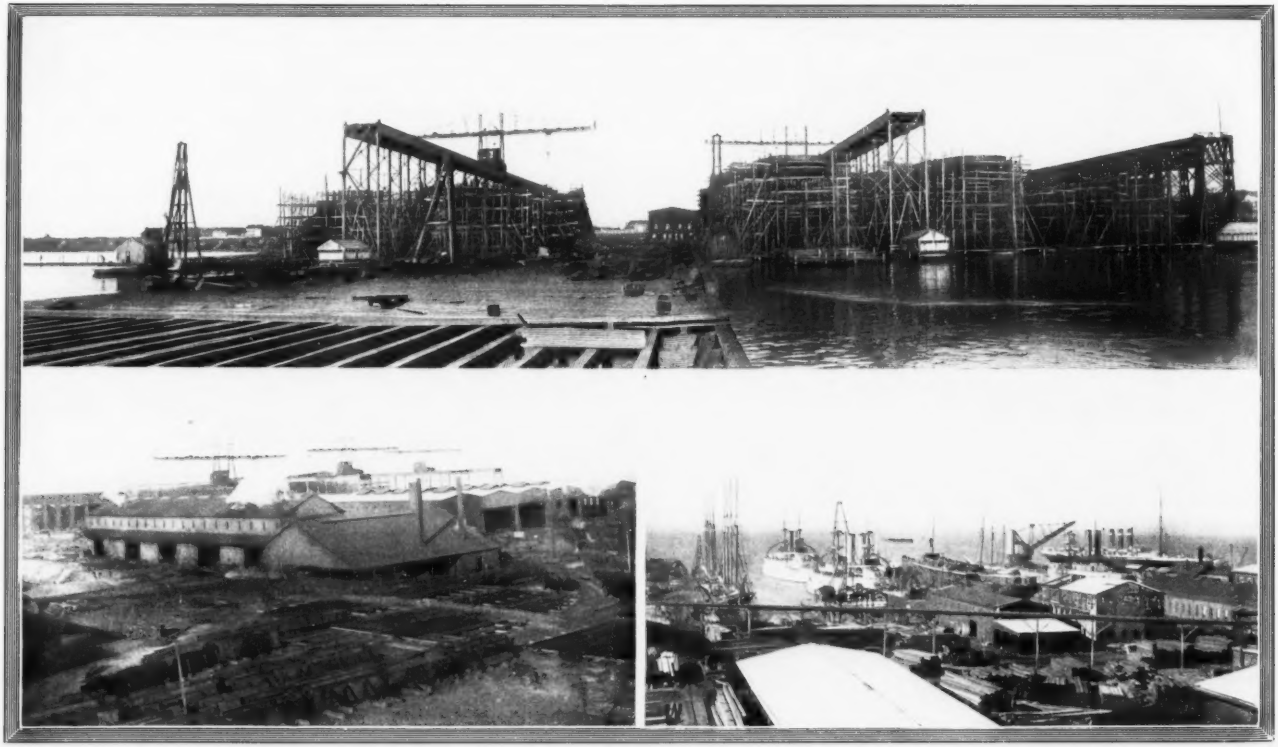
INTERIOR OF MAIN MACHINE SHOP, UNION IRON WORKS.



ERECTING SHOPS OF THE UNION IRON WORKS.

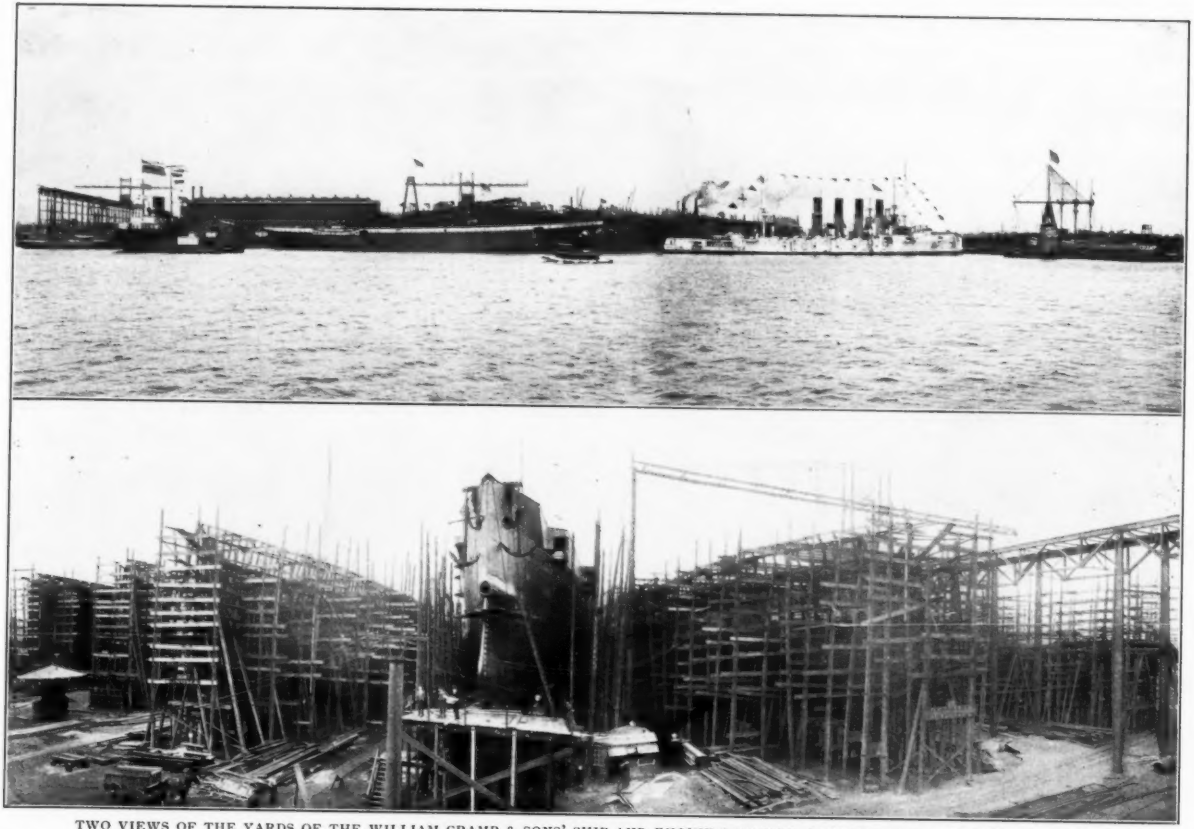
In the main shop, shown in the upper picture, the work on the floor includes 12,000-horse-power engines for the United States battle-ship Ohio, twin engines for freighter Alaskan, electric-light engines, and general work; in the small shop, below, the conspicuous feature is the group of six engines for three torpedo-boat destroyers, 4,000 horse-power each.

TYPICAL AMERICAN ENGINEERING WORKS. NEWPORT NEWS SHIPBUILDING AND DRY-DOCK COMPANY, NEWPORT NEWS VA.
Interior view of main machine shop, from erection end.



VIEWS IN THE PLANT OF THE NEWPORT NEWS SHIPBUILDING AND DRY-DOCK COMPANY, NEWPORT NEWS, VA., U. S. A.

The upper picture shows the north end of the yard, with six ships on the ways; below on the left is a general view from the main office building, looking north, showing the three great cantilever cranes; on the right is a partial view of the lumber department and outfitting slips, showing the 150-ton electric-driven revolving derrick Hercules.



TWO VIEWS OF THE YARDS OF THE WILLIAM CRAMP & SONS' SHIP AND ENGINE-BUILDING COMPANY, PHILADELPHIA, PA , U. S. A.

The upper one shows the general water front. At the left is the Morro Castle, the new record breaker between New York and Havana. Next her is the Sierra, which has just made a new record between New York and San Francisco, and next her again the Russian cruiser, Variag. In the slips behind are building the Russian warship Retvizan, the U S. battle-ship Maine, and the Ventura and Sonoma, of the Oceanic S. S. Co., sister ships to the Sierra. The lower cut shows the Variag on the stocks, with the Retvizan on the right.

THE RELATION OF THE STEAM ENGINE TO MODERN ECONOMIC PRODUCTION.

By F. R. Hutton.

IT is a principle which has been recognized by all writers upon the theory of economics that a proper definition of production must include the expenditure of labor upon raw material, or a product of natural law, whereby its utility to the consuming community shall be enhanced. It is a manifest corollary to this definition of production that the greater number in any community will be able to derive benefit by articles so produced, in proportion as the value of these articles to the producers approaches more nearly to the actual cost of their production. This is, of course, the same thing as to say that the largest market will be found when the largest number of persons are in a position to need and to purchase. Hence, it has become almost an axiom of the present trend of economic production that the most satisfactory returns come from very large outputs of product, in which the profit in each article is small but the aggregate is large.

The very great output of modern establishments and the corresponding economic advantages of such great output are the result of the application of four principles in production, of which America has, perhaps, been the most considerable representative. These are:

1. The Factory System.
2. The Division of Labor.
3. The Special Tool.
4. The Interchangeable System.

Leaving for the present the consideration of the last three items, as covering an area too extensive to be satisfactorily discussed in

The millions of industrial workers of to-day owe their employment, in many instances largely and in others wholly, to the use and the constantly increased economy of machinery. The agency which labour at the outset fought most bitterly, under the delusion that it was its deadly enemy, has proved its Providence—the only conceivable salvation in the crowding struggle for employment. Labour-saving machines have founded, fostered, and filled labour-providing factories.

It should be clear to all that every advance in labour economy will bring the same happy result. The history of the steam engine is the forecast of every movement, either in mechanical invention or methods of management, which tends to lessen or cheapen the labour of production. The certain result of either is vastly enlarged opportunity and augmented reward for the workman.—THE EDITORS.

connection with the first one in the limits of a single article, and turning attention to the first element alone, it will appear that this also is made up of a large number of contributing elements. The factory system has been the step which has succeeded the former method, which may perhaps be called the "Domestic System."

In the domestic system every operator was an individual, working with the tools of his trade in his own house and with the equipment which these conditions imposed. The purchase of the raw materials and the sale of the finished product in the true domestic system formed a series of transactions on a very small scale on the basis of very limited capital. So many objections presented themselves from these points of view that even under the domestic system it was quite usual for the "factor" or master workman to provide for the purchase and sale of raw material and product in the interests of a large number of his work people, for whom he acted as trustee or agent. It will further be apparent that under that system, supervision and inspection, if done at all, were done under great disadvantages and at what would be considered enormous expense under our present conditions. It was scarcely possible that either mechanical appliances on any large scale, or improvements in the tools of the trade, could be procured by workmen under the domestic system, and the application of science and invention would be relatively slow to percolate through the mass of workers, if there were any notable inducement for the making of such applications under that less favorable condition.

It is, however, to the great limiting condition of the domestic system that this article is particularly directed. This limitation is the limited output of the individual, when, besides the knowledge of brain and skill of hand, the laborer must also furnish the endurance of muscle to perform the work of overcoming the resistance in the process of fabrication, whatever it may be. If it was a weaving industry which was in question, the weaver must run the loom as well as tend it; if it were the shaping of metal, the blacksmith must furnish great capacity to endure hard muscular labor; if it were the shaping of wood, the force required to separate its particles must be supplied, as well as the deftness of touch and eye to bring out grace and beauty.

On a step higher than these conditions, where the labor of the human muscle was drawn upon, the historian comes to the places where the labor of animals, such as horses, was made available for hoisting, for pumping, for grinding, and, of course, mainly for transportation. Even here, however, must still be met the noteworthy limitation. The animal tissue and the vital energy wasted in muscular

toil must be recuperated by periods of rest, so that the number of working hours per day of the animal motor has to be kept at a relatively low figure. The expense of the fuel material furnished to the animal motor, in the form of food, is relatively large, and the limitations imposed upon the magnitude of the effort in foot pounds which such a motor can exert for any length of time, keeps all production on a very limited scale as compared with the standards set by the modern requirement. This discussion, furthermore, says nothing whatever upon the humanitarian, or non-material, questions relating to the effect upon the human species of holding him down to a life of unremitting, hopeless, muscular toil, as compared with the uplifting effect of freeing him from the mere animal part of self-support and enabling him to make use of his higher faculties in the process of bread-winning, with the higher pleasures which come to him from this exercise.

It is not too much to say, therefore, that the factory system, with its advantages to the community in the production of its wealth and in the putting of more articles within the reach of the purchasing power of more persons, could not have been made possible without the introduction of sources of motive power to supply that which the factory demanded for the conduct of its processes. The factory brought together a large number of workmen with their appliances for production, and put them under a common supervision with a common source of motive power. The enormously increased production which followed from the combination of all the advantages of the factory system made it possible to arrange for systems of purchase and sale of great advantage to the operatives, on the one hand, and to the community on the other. The aggregation of large numbers of workers made it economically defensible to increase greatly the importance of the machinery of production, and the increased value of the larger volume of output made it significant to induce the application of science and invention to increase the effectiveness of the equipment; so that by introduction of the improved sources of motive power, the modern system is fairly launched.

In tracing the development of the domestic system into the factory system, the historic period is comparatively short. Previous to the introduction of important systems of transportation of goods from one point of production to a market at a distance, nearly all industries were relatively limited to the local consumption in their immediate neighborhoods. The weavers made for themselves and their village; the worker in iron served his community; the farmer raised for himself and the limited number of trades-people who supplied his needs;

the wood-worker made his constructions for those who could call on him from a relatively narrow area. Obviously, therefore, one of the first and greatest developments from the earlier stage to the later would come about with the introduction of the power looms, on the one hand, and the introduction of the processes which made the railroad possible, upon the other. The early third of the eighteenth century and its latter half are the dates to which the student is directed for looking up these tendencies, and mainly in England. Furthermore, until the coming in of the steam-engine, up to which time water power was the only source of considerable units of motor energy, the limitation of production by location favorable to such water-power development would keep the economic growth of a country within narrow limits. We find certain districts in England growing up and becoming important under this favoring condition of their location with respect to water courses, and the same thing in America in those parts of New England where water privileges were to be found and utilized. The wealth-making capacities of the country were awaiting such inventions and improvements as should enable the producing institutions to become widespread.

It is a well-known fact to all students of the early history of the steam-engine, that its first growth was in the mining and other districts where pumping was a considerable problem to be met. The first engines of Savery, Newcomen, and Lord Worcester's inventions were applicable exclusively to pumping, and it was not until James Watt's devotion to the motive problem developed the crank and fly-wheel shaft type, in which the reciprocating motion of the piston could produce continuous rotation of a crank shaft, that the steam-engine became the handmaid of the factory system, in the latter end of the eighteenth century. By replacing the muscle of the human or animal subject by a force tirelessly supplied from the combustion of coal, the problem of aggregation of motive power and its continuous action up to its maximum of effective output became the simple but fundamental condition of modern production. By using the constant and controllable energy of the fuel consumed, instead of the variable and uncertain volume of energy resulting from falling water, a continuity of employment for the laborer and of regularity in the flow of product became the expected, rather than the unusual, condition. It became possible to increase greatly the unit or aggregate of motive power, with all the advantages entailed by bringing such larger units under the supervision of a diminished staff.

It is not an easy process to make a computation which shall appear

to have anything like fairness in a comparison of the relative costs of human or animal motors and the motors which use steam. If it be conceded that, taken for a considerable number of hours, the average output of a human unit is about one-tenth of a horse power, we shall require ten men for each horse power of energy delivered. If the type of human motor employed for this purpose was of an exceedingly low grade in the intellectual or any other scale, it might be obtained for a dollar a day. At $10 a day, therefore, for the horse power on the above calculation, and for 300 working days in the year, we should expend $3,000 for the horse power per annum. The calculations which have been made by the best experts concerning the cost of a horse power per annum, as developed in large-size plants through New England, for technical purposes, would seem to indicate that the cost should rarely exceed $35 per annum if the plant is developing its own steam power on a large scale, and it may fall as low as a little over $20. The charge for water-power privileges on a large scale, as made by some of the best authorities, would indicate that it is likely to be a little higher than the above figure for the steam-power plant, but that it will rarely be less than $50 per annum and may rise as high as $100 for the hydraulically-driven mill. This shows still an enormous margin of economic advantage for the aggregation made possible by the development of the steam-engine, both intrinsically or absolutely and relatively. The relative gain is the result of distributing the charge for motive power over a large number of producing units, each of whom draws only his own requirements of motor energy from the central source, whereas under the domestic system a very much greater aggregate of motor energy is used, by reason of wastefulness of each individual unit by itself.

It is also a well-known principle of the generation of steam power that the proportionate economy increases as the size of the unit increases. There are certain unavoidable losses which are represented by a certain volume of cylinder which has to be filled and exhausted at each stroke, and this relative volume is much smaller with a large cylinder than is that volume with a small one. It has therefore been a sequence of the development of large machine tools, whereby large engine units have become possible, that the development of the large engine has kept pace with the development and increase of the output. This has still further diminished the motive-power charge to be made to each producer-unit, or unit of product, and is a consequence favorable to the theory that the great aggregation of capital resulting in a great establishment is a condition favorable to economic production.

It is a logical consequence and normal growth of the principle of aggregation as represented in the gathering together of workers in the fundamental factory unit. This consideration opens up, furthermore, a most interesting line of thought for future study and observation, when there shall have been more general extension of the principle of generating power in some satisfactory form at a central station of enormous capacity and distributing it to a large number of factory units. It will be apparent that if each factory unit paid the same price for motive-power unit per annum that it is now expending, the aggregation of these large users by the reduction of general and non-productive expense in the development of the power could pay a good profit on the generating enterprise, or the co-operation of the factory units to own the large generating plant themselves could secure for them their motive power at less than the price of the smaller unit. It should be observed, however, with respect to this conception, that when the unit becomes a certain size there is little or no additional economy consequent upon duplicating or multiplying that unit by another factor. That is, when the unit is as large as 1,000 horse power, the economy resulting from increasing the size of the units by simple multiplication becomes inconsiderable or disappears. The 5,000 unit is five times as expensive as the 1,000 unit, so that the cost per unit is the same.

It is interesting in reverting to the domestic principle, to call attention to the fact that in this system the losses incident to transmitting power are little or nothing. The friction of the machine driven by the man's foot is the only loss, and this the factory method does not eliminate. On the other hand, where a large number of machines are driven from a central source of motive power the friction incident to the old method of transmitting power through shafts, gears, belts, and the like, becomes a considerable rebate or discount upon the economies of the concentrated motive-power unit. It is rare that the friction of transmission machinery in any considerable plant is as low as 20 per cent. of the motive power transmitted, and with bad arrangements of the buildings and defective maintenance on the one hand, and with a very large number of light tools on the other, may rise to 40 per cent., and even more. This would point to the enormous advantages incident to the transmission of the power by electrical means, whereby the expense and loss incident to defective transmission can be so materially reduced. If the transmission friction is as low as 20 per cent., the losses in the transmission of the electrical energy about balance out. At greater losses the electrical method comes out ahead.

In the problem of the application of motive power to transportation as a form of production, in the sense that it increases the value or utility of a product, the significance of the development of motive power transcends almost any other consideration. A somewhat impressive example can be derived from the rough calculation of the meaning that would attach to a Transatlantic liner with a 20,000 horse-power engine were that engine to be replaced by 20,000 horse power of human muscles. To run night and day there would have to be three relays of men at the treadmill or other appliance which would be used. Each eight-hour shift at each 10,000 horse-power engine would be 100,000 men, or 200,000 for the two engines. Three shifts of 200,000 men would give below decks a population of a city of second grade. If the problem, moreover, were put in the form of high-speed transportation, such as is represented by the locomotive condition, it disappears practically in the field of the unthinkable. It needs, therefore, but a moment's consideration of the widespread significance which the railroad bears to the modern economic method to bring out the debt which the modern community owes to the motive-power problem, as solved on the railroad. The supply to cities and to their working multitudes of the food in the form of milk, grain, and meat which they require; the distribution of the product of the farm to the market which is to consume it; the disposition of the product of the mill and the factory to the market as extensive as the world—these are the consequences of our modern methods of transportation; all these are recognized as dependent upon the development of the steam-engine. The discussion might further be extended to include the meaning of the pumping engine to the water supply of our large cities (which latter are the direct consequence of the factory principle) and the consolidation of large numbers of workers into one dense area, upon which they expend themselves in the wage-earning processes. The elevator is only a form of the railroad, but the value of property covered by a tall building is a function of the service which the engineer has rendered in making the top floors available.

There are three interesting conclusions which seem to be capable of being drawn from the discussion which has preceded.

The first is that the mechanical engineer, of all the specialists in his great profession, is that type whose influence upon economic production and the prosperity of the community is the greatest. It is he who has developed the economical steam engine, which lies at the root of the factory system, with the economies which this article has aimed to bring out. It is he who has developed the special machinery of

production in the factory, with the economies incident to the greatly increased productivity of the plant and the worker in it. It is he who has applied to the productive processes the knowledge of the laws of force and matter which is called science.

The second conclusion is that it is sound economic theory to attach the skill and ability of the engineer directly to the producing process. This is a tendency of the American method, which manifests itself in the growth of that principle whereby the producer is made responsible for achieving a result which is desired by the consumer or buyer of his product, while the latter does not impose upon him the methods, by specification or otherwise, whereby these results are to be attained When this method is followed the compensation of the engineer is a charge upon the great output of the producing establishments, and is a charge, furthermore, distributed over a large number of units and is imposed at the moment of the production of their cost. When the consulting engineer is employed as a factor or agent of the buyer or consumer, his compensation is a charge upon the wealth of the community which has been already produced. The community is therefore impoverished to the extent that such engineer is a consumer, and not in the economic sense a producer.

The third conclusion is that there is no logical stopping place for a mind which has admitted the superiority of the factory system, with its effect upon economic production, which seems to be conceded on all sides, until the thinker has carried consolidation upward to the "trust." Or, in other words, the foregoing discussion should constitute a valid argument in favor of the tendency to consolidation and combination which is popularly designated as the trust idea. A grouping together of individual workers is a factory; a grouping of several departments contributing to a common product becomes a plant; a grouping of several plants, each controlled by its own corporate organization, is a trust. The trust, therefore, would appear to reap the advantages of the factory, so far as diminishing the cost of production is concerned, as compared with the cost of production of a number of individual plants working against each other with their own proportion of non-productive expenses. While the trust in its ordinary form and under selfish and short-sighted management is mainly in evidence to the community by its effort to raise the selling price by means of the methods of restricted production or monopoly in production, these are abuses of the principle of consolidation. The economic defence for consolidation which is conceded for the factory should be conceded for the well-managed trust also.

THE TAYLOR DIFFERENTIAL PIECE-RATE SYSTEM.

By Sanford E. Thompson.

NO question, perhaps, is exciting more interest at the present day than the labor problem. It is viewed from every conceivable stand-point, and real harmony between employer and employed is looked upon as scarcely more than a Utopian possibility. And yet in nearly every community there are certain establishments, sometimes small and sometimes those employing thousands of hands, in which the best of feeling exists between the employees and the management, in which there is an honest day's pay for an honest day's work, and in which the same men have worked year after year.

The solution of the problem lies, not in compelling either labor or capital by law or coercion to receive or to pay certain fixed wages—not even by merely "creating public sentiment"—but, to a far greater degree, both in industrial establishments and in structural work, through the adoption of methods of management which have been tried and proved.

Nearly fifteen years ago a system of management was introduced by Mr. Fred W. Taylor, of South Bethlehem, Pa., in the works of the Midvale Steel Company of Philadelphia, which has been employed by them with so satisfactory results that it has been introduced into several other large manufacturing concerns. The paper presented by Mr. Taylor before the American Society of Mechanical Engineers, describing this system, has awakened such an interest among those

The piece-rate system is one of the most troublesome questions still unadjusted between employers and employees. It is so manifestly in the line of reason and of progress in the economy of production that the final outcome is in no sort of doubt. Some form of payment by which wage is proportioned to output is sure rapidly to supplant the "day's-work" system. Any method of so presenting or so adjusting a rational plan of piece-working that it may commend itself by its fairness to both sides, is an invaluable service to the manufacturing world. It is in this spirit that Mr. Thompson's article is presented. It has had the revision and approval of Mr. Taylor himself.—THE EDITORS.

interested in manufacturing and also among scientific men, that, with the permission of the author, a revision of the article has been undertaken. With this are presented some results of the system which have come under my observation during my connection with Mr. Taylor in several establishments.

That the ordinary system of piece work will, in general, stimulate a man to do a larger amount of work than he will perform when employed by the day is acknowledged by all who have had experience in the employment of labor; but the methods usually employed involve a permanent antagonism between employers and men, and a punishment instead of a reward for a workman who reaches a high rate of efficiency.

The system introduced by Mr. Taylor consists of four principal elements:

1:—An elementary rate-fixing department.

2:—The differential-rate system of piece work.

3:—A systematic over-inspection of material produced.

4:—The management of men who work by the day by methods which reward ability.

In elementary rate-fixing, instead of recording the time for doing whole jobs and fixing the rate on new work by guess, rates are fixed on every elementary operation throughout the establishment and the price of any piece of work is obtained by adding together these detail rates. The simplicity of this method in actual practice will be described later on.

The differential-rate system of piece work consists in offering, for the same job, a high price per piece if the work is done in the shortest possible time and in a perfect condition, and lower prices per piece for slow and imperfect work.

Over-inspection is the means of detecting imperfections in the product.

Mr. Taylor's system of management of men who are on day work consists of paying men, and not positions.

The advantages of this system of management are:

First:—Manufacture is cheapened, and, at the same time, higher wages are received by the workmen.

Second:—A more uniform quality of product is obtained than that resulting from day work or ordinary piece work.

Third:—Rates are fixed by scientific methods and the motives for "soldiering" are removed, while the men are treated with greater uniformity and justice, and it is for the common interest of both manage-

ment and men to turn out a maximum quantity and the best quality of work.

Fourth:—The system is rapid in attaining the maximum productivity, and the maximum is automatically maintained by the differential rate.

Fifth:—The men best fitted for each class of work are automatically selected and the lazy and inferior are sifted out.

Finally:—One of the chief advantages derived from these effects of the system is that it promotes a most friendly feeling between the men and their employers, and so renders labor unions and strikes unnecessary. There has never been a strike under the differential-rate system of piece work, although it has been in operation for the past fifteen years in the steel business, which has been, during this period, more subject to strikes and labor troubles than almost any other industry.

In the manufacturing, or productive branch of the establishment there is opportunity for greater waste and loss than even in the commercial and financiering departments, and the problem confronting one is the necessity for the establishment of a system which is so automatic in its workings as to prevent the dependence upon a single man and to produce harmony between the employer and the employed. The old-school manufacturers believed in men, not methods, in the management of their shops, and their keen insight and knowledge of character enabled them to select and train good superintendents, who, in turn, secured good workmen. The modern manufacturer seeks not only to secure the best superintendence of workmen, but also so to surround each department of his manufacture with a carefully woven network of system and method as to render the business less dependent upon one man, or even upon a combination of men.

Before describing the differential-rate system it is desirable to consider briefly the more important of the other methods.

The simplest of all systems is the day-work plan, in which the laborers receive one rate of pay, all the machinists another rate, all the engineers another, and so on. The men are paid according to the position they fill, without regard to individual character, energy, skill, and reliability. Is it strange that under this system even the most ambitious men soon conclude that there is no profit to them in working hard, but that the best thing for them to do is to work just as little as they can and still keep their positions? It is just this plan that necessitates the formation of the labor union, and produces the antagonism between employer and employed which results in the strike. The neces-

sity for the labor union disappears when the *men* are paid, and not the *positions.*

Every manufacturer must, from necessity, employ a certain amount of day labor which cannot come under the piece-work system; and yet, how few employers are willing to go to the trouble and expense of the slight organization necessary to handle their men in this way! And how few of them realize that by the employment of an extra clerk and foreman, and by the use of a simple system of labor returns to record the performance and re-adjust the wages of their men so as to stimulate personal ambition, the output of a gang of twenty or thirty men can be readily doubled in many cases, and at a comparatively slight increase of wages per capita! A clerk in the factory is the horror of the old-style manufacturer. He realizes the expense each time he looks at him, and fails to see any adequate return. Yet, by the plan here described, the clerk becomes one of the most valuable agents of the company.

Then the question arises: If a system of day work operated by these methods, in which the pay of each man is regulated by the quality and quantity of his work, is so satisfactory, why is there a necessity for piece work? The answer is: Because it is impossible for a foreman to watch all his men all of the time, and the method of recording is more complicated than with piece work.

The step from systematic day work to ordinary piece work is a short one. Where records have been kept, the work has, of course, been divided into sections, and the usual time for doing the work by different men has been recorded; from these records the piece rate may be made. But ordinary piece work has to be in operation but a very short time before its defects are manifest. Each workman with a definite price set for his product contrives to do his work by shorter methods and therefore to make larger the profit to himself. The employer at once decides that he must have a share in these profits, and the rate is cut. After this has happened once or twice, the men perceive that they are getting practically nothing for the extra work and skill which they put in, and they immediately commence to gauge the amount of work which they do. They decide that they can easily turn out a certain amount of product and that, if they turn out no more than this, their employer will maintain the present rate; but if they increase it so that they get too large an amount of money per week, there is a cut. If the leaders among the workmen are shrewd, they can thus maintain a constancy of product greatly below the maximum which would result if each man really did his best. It is a fact that

some of the labor unions, where the members are employed by the piece, fix a maximum day's work, and no man is allowed to exceed it for fear of a cut in rates.

Another way in which the workman obtains high rates in ordinary piece work is by starting very slowly upon a new job. As rates are usually made, day work is necessary at the start, and men may often work at one-third or even one-fourth of their maximum speed and yet appear to be working hard. One method of avoiding this "soldiering" is for the manufacturer to establish rates for a definite time, which tempts the men to let themselves out even at the risk of a reduction in pay at the end of the period.

One or two variations of ordinary piece work have been introduced which require notice. One of these is "gain sharing," which was introduced by Mr. Henry R. Towne in the Yale & Towne Manufacturing Company, Stamford, Conn. Another is the "premium plan of paying for labor," introduced by Mr. F. A. Halsey. Mr. Halsey's plan allows free scope for each man's personal ambition, while Mr. Towne's does not recognize the personal merit of each workman, and the tendency is to herd the men together. In both of these plans there is a temptation for the men to hold back on day work, especially where rates are being fixed. Then again, each new job requires entirely new observations, and rates in different departments are based upon the work of different men at different rates of speed, and, are therefore, variable. The defects of the two systems may be briefly stated thus:

1:—The methods of operating are slow and irregular, depending upon the men upon whom observations are taken.

2:—They fail to attract superior men and to sift out inferior ones.

3:—They do not automatically insure a maximum production.

Co-operation, or profit sharing, has met with partial success. In theory, the general scheme of this system is exceedingly fine, but there are, in practice, several conditions which render it impossible for it to meet with widespread and uniform success. In co-operative establishments the individual has not a scope for his personal ambition. The man who is intelligent or capable of doing a larger amount of work than his fellows, when he sees his fellow workmen in a mill employing one hundred hands receiving 99/100 of the benefit accruing from his extra skill or labor, has very little to stimulate him to continue his extra work. Then, too, the remoteness of the reward prevents men from working at their maximum capacity. Comparatively few men are capable of working for a reward which is a year or more distant, whereas if it comes to them in the form of dollars and cents at

the end of the week, its worth is appreciated. Another, and perhaps the most serious, objection to co-operation is the fact that while the workmen are willing to share the profits, they are unwilling and unable to share the losses.

The real antagonism between men and their employers under ordinary piece work is due on the part of the men to *the universal desire to receive the largest possible wages for their time,* and, on the part of the employers, to *the desire to receive the largest possible return for the wages paid.* Is it any wonder that most of us arrive at the conclusion that no system of piece work can be devised which can enable the two to co-operate without antagonism and to their mutual benefit?

Mr. Taylor lays down the following laws as a basis for harmonious co-operation between employers and employed:

First:—That the workmen in nearly every trade can and will materially increase their present output per day, providing they are assured of a permanent and larger return for their time than they have heretofore received.

Second:—That the employers can well afford to pay higher wages per piece, even permanently, providing each man and each machine in the establishment turns out a proportionately larger amount of work.

The truth of the last statement will be seen when one considers the effect of the volume of the output upon the cost of production. The indirect expenses—which include taxes, insurance, depreciation, rent, interest, salaries, office expenses, miscellaneous labor, and sales expenses, usually amounting in the aggregate to as much as the wages paid to the workmen—remain nearly the same whether the output of the establishment is large or small. It is not unfair to assume that these fixed charges do equal one-half the total expense. Suppose, then, that the men turn out double the amount of work per machine that they have been accustomed to do. Even supposing their rate per piece to be the same as before, there is a saving in the cost of production of 25 per cent., due to the fact that so large a proportion of the expenses remain constant.

In our endeavor to solve the piece-work problem by the application of the two fundamental facts above referred to, let us consider the obstacles in the path of harmonious co-operation, and suggest a method for their removal. The most formidable obstacle is the lack of knowledge, on the part of both the men and the management, of the quickest time in which each piece of work can be done. The remedy for this trouble lies in the establishment of the proper rate-fixing department, organized and conducted in as scientific and practical a

manner as are the engineering and managing departments. Rate-fixing for ordinary piece work is done by a foreman or superintendent who, with the aid of a clerk, looks over the record of the time in which a whole job as nearly as possible like the new one was done, and then guesses at the time required to do the new job. No attempt is made to analyze the time, the classes of work, or the elements of which a job is composed. It is really a far simpler task to resolve each job by Mr. Taylor's methods into its elements, to make a careful study of the quickest time in which each of the elementary operations can be done, and then properly to classify, tabulate, and index this information and use it when required for rate-fixing, than it is to fix rates even with an approximation to justice under the common system of guessing.

A suggestion that this is a practical way of dealing with the piece-work problem usually meets with derision, or, at best, with the answer that "It might do for some simple business, but my work is entirely too complicated." Yet this elementary system of fixing rates has been in successful operation for the past fifteen years on work complicated in its nature, and covering an extreme range of variety in manufacture.

In 1883, while foreman of the machine shop of the Midvale Steel Company of Philadelphia, it occurred to Mr. Taylor that it was simpler to time each of the elements of the various kinds of work done in the place, and then to find the quickest time in which each job could be performed by summing up the total times of its component parts, than it was to search through the records of former jobs and guess at the proper price. It was soon evident that the system was a success, and a rate-fixing department was established which has given out piece-work prices in the place ever since.

A more complicated and difficult system of rate-fixing could not be found than that of determining the proper price of doing all kinds of machine work on miscellaneous steel and iron castings and forgings, which vary in their chemical composition from the softest iron to the hardest tool steel. Yet this problem was solved through the rate-fixing department and the "differential rate," with the final result of bringing complete harmony between the men and the management, in place of the constant war that existed under the old system; at the same time the quality of the work was improved and the output of the machinery and the men was doubled and, in many cases, trebled. At the start there was naturally great opposition to the rate-fixing department, particularly to the man who was taking time observations for the various elements of the work; but when the men found that the

rates were fixed without regard to the records of the quickest time in which they had actually done each job, and that the knowledge of the department was more accurate than their own, the motive for hanging back or "soldiering" on this work ceased, and with it the greatest cause for antagonism and war between the men and the management.

As an illustration of the great variety of work to which elementary rate-fixing has already been successfully applied, it will be of interest to note that Mr. Taylor, while acting as general manager of two large sulphite pulp mills, directed the application of piece work to all the complicated operations of manufacturing throughout one of these mills by means of elementary rate-fixing, with the result within eighteen months of more than doubling the output of the mill.

The difference between elementary rate-fixing and the ordinary plan can be best illustrated by an example. We will suppose that the operation consists of boxing marbles of various sizes and with varying quantities to a box. The entire operation will consist of the following details: getting box, opening box, counting marbles, pouring in marbles, putting on cover, labeling, and setting aside. Instead of timing the complete operation in gross for every size or quantity of marbles, the individual operations are timed. Suppose that, by timing each detail and adding the results, a rate is fixed for one size and one quantity. When a rate is desired for another size and quantity, all the timing necessary may be the counting of the marbles, for the times consumed in work upon the box may be the same as in the other size. Where merely the quantity differs, the time may be obtained by taking a multiple of the time already found for the quantity in the other case, and combining this with the other details. In other words, many of the times of the details remain constant under all conditions. As to the accuracy of this method, all that can be said in so brief an article is that it has been proved to be correct in practice. It has not only the advantage of accuracy, but rates thus obtained are sure to be relatively correct.

The elementary system of rate-fixing is of so great importance that an example taken from Mr. Taylor's paper is given below, illustrating the method of analyzing a machine-shop job. Suppose the work to be planing a surface on a piece of cast iron. In the ordinary system of piece work, the rate-fixer would look through his records of work done by the planing machine until he found a piece of work as nearly as possible similar to the proposed job, and then guess at the time required to do the new piece of work. Under the elementary system, however, some such analysis as the following would be made:

WORK DONE BY MAN.

	Minutes.
Time to lift piece from floor to planer table	——
Time to level and set work true on table	——
Time to put on stops and bolts	——
Time to remove stops and bolts	——
Time to remove piece to floor	——
Time to clean machine	——

WORK DONE BY MACHINE.

	Minutes.
Time to rough off cut ¼ in. thick, 4 ft. long, 2½ in. wide	——
Time to rough off cut ⅛ in. thick, 3 ft. long, 12 in. wide, etc	——
Time to finish cut 4 ft. long, 2½ in. wide	——
Time to finish cut 3 ft. long, 12 in. wide, etc	——
	——
Total	——
	Minutes.
Add —— per cent. for unavoidable delays	——

It is evident that this job consists of a combination of elementary operations, the time to do each of which can be readily determined by observation, and while this exact combination of operations may never occur again, elementary operations similar to some of these given will be performed in differing combinations almost every day in the same shop. The rate-fixer soon becomes so familiar with the time for each of the elements that he can write them down from memory. For the part of the work which is done by the machine, he refers to tables which are made out for each machine, giving the time required for any combination of breadth, depth, and length of cut.

It is one thing to know how much can be done by the workmen and an entirely different matter to get even the best men to work at their fastest speed. The method found to be the most effective in obtaining a maximum output of a shop was by means of the differential rate.

The differential-rate system of piece work consists briefly in paying a higher price per piece (or per unit, or per job), if the work is done in the shortest possible time and without imperfections, than is paid if the work takes a longer time or is imperfectly done. Perhaps the simplest way of describing the differential rate is to give an illustration. We will suppose that in a certain kind of work a man finishes when working nearly at his maximum speed, twenty pieces per day. The rate, then, for twenty pieces per day may be fixed at 15 cents per piece, making his day's pay $3.00. If, instead of turning out twenty pieces, he turns out only nineteen, his rate, instead of being 15 cents, may be 12 cents per piece, or $2.28 per day, scarcely more than he received when working by the hour. If, on the other hand, he turns

out twenty pieces and some of them are of inferior quality, there may be a deduction of, say, 5 cents per piece, so that he receives for the entire twenty at the rate of 10 cents per piece, or $2.00 per day.

Now, what would have occurred under the ordinary piece-work plan? Let us suppose that, under the ordinary system of piece work, the workman has been turning out sixteen pieces per day at the rate of 15 cents per piece, making his day's wages $16 \times 15 = \$2.40$. Through extra exertion he succeeds in increasing his output to twenty pieces per day, and so increases his pay to $3.00. Now we come to one of the fundamental differences between Mr. Taylor's methods and the common practice in piece work. The employer under the old system sees that this workman is earning $3.00 per day, while other men are only getting from $2.25 to $2.50, and accordingly he immediately cuts the price from 15 cents per piece to 12 cents, and the man finds himself working very much harder and yet earning only the same old wages, $20 \times 12 = \$2.40$ per day. Is it strange that men do not care to repeat this performance many times? Can anyone blame them for making a rule among themselves that a certain output shall not be exceeded?

In any system of management a principle which must always be recognized is that *a man will not do an extraordinary day's work for an ordinary day's pay,* and any attempt on the part of the employers to get the best work out of their men, and at the same time pay them no more than the standard wages paid by their neighbors, will surely be, and ought to be, doomed to failure. Justice, however, not only demands for the workman an increased reward for a large day's work, but should compel him to suffer an appropriate loss in case his work falls off either in quantity or quality.

The differential rate satisfies automatically the conditions of properly graded rewards and deductions. Whenever a workman works for a day, or even a shorter period, at his maximum, he receives unusually high wages provided he does perfect work. If his work is not up to the standard in quality, however, he may receive less pay than a good workman who does a considerably smaller amount of work. The great advantage of the differential-rate system is that it quickly drives away all inferior workmen and attracts the men best suited to the class of work to which it is applied. None but really good men can work fast enough and correctly enough to earn the high rate, and the low rate should be made so small as to be unattractive, even to an inferior man.

If for no other reason than that it secures to an establishment a

quick and active set of workmen, the differential rate is a valuable aid, since men are largely creatures of habit. If the piece workers of a place are induced to move quickly and work hard, the day workers soon get into the same way and the whole shop takes on a more rapid pace. The differential rate acts automatically, and punishes the poor workman for imperfect work as well as rewards the good man for perfect work.

One of the most important branches of a proper piece-rate system is the over-inspection. Unless one has been personally acquainted with the effects of a careful system of piece-work management, the conclusion is formed that, if an extra quality of product is desired, even in an establishment customarily employing piece rates, day work must be resorted to. In actual fact, the contrary is absolutely true. This is, perhaps, best illustrated by an example of piece-rate methods which have been introduced by the writer under the direction of Mr. Taylor in a manufacturing establishment. The work in the department under consideration consisted of the examination of material produced in other departments. Until Mr. Taylor undertook the introduction of his piece-rate methods, this work was done by the day. After the piece-rate system had been in operation in the department for three months, the employees were doing just twice the amount of work per day that they did before the system went into effect. They were doing this quantity of work in eight and one-half hours instead of ten and one-half under the old management, and they were turning out a quality of product which by actual unbiased test showed an improvement of about 25 per cent. over previous work. The improvement in quality was obtained by thorough over-inspection. Over-inspection, where possible, should isolate the work of each man, so that each will receive pay for his own work and the total will depend entirely upon himself. Where, however, the work is done in small gangs, the result is nearly as satisfactory as where each man's work is separated, because the good men force the drones either to work hard or to quit.

A proper rate-fixing department is an essential to any piece-rate system, and is, in fact, by far the most important branch of the work. It is not within the scope of this article to describe the proper methods of making up rates, but a scientific course should be followed and no rates made by guess. A careful study is necessary of the capabilities of the machines and the speeds at which they must run. Records of the times of doing work under all conditions must be most carefully made and tabulated.

The most important results of piece-rate methods, such as introduced by the system described, are the promotion of a proper mental attitude between the men and the management. It is for the interest of both to co-operate and turn out a maximum quantity and the finest quality of work. The indirect results attained are by no means small. It is absolutely necessary for the machines to be kept in good repair. If a machine breaks, the workman will either repair it himself to avoid loss of time in hunting up some one else to do it, or will report it before it commences to affect the material. Defects in the design of the machinery are brought to notice, and improvements suggested both by the management and the men. It is necessary, also, to systematize the other details of manufacture in such a way that there will be smooth running and no friction in any of the departments.

The object of the differential-rate system is not to force a man to over-exert himself, but to permit of a "natural selection" whereby men gradually sift themselves into jobs for which they are fitted by nature and training. For example, in shovelling coal from a car over the side onto a pile, the man who may be, perhaps, so mentally inert as to prevent him from any attainments which require skill, will unload 40 tons per day and keep it up year in and year out and thrive under it. This is not a supposition, but a statement of what is actually being done. Accordingly, men may be found anywhere who are glad to work at a piece rate of from 4½ to 5 cents per ton and will make good wages. Yet the average speed for unloading coal, in most places, is nearer 15 tons than 40 tons per day.

A standard steel forging, many thousands of which are used each year, had for several years been turned at the rate of from four to five per day under the ordinary system of piece work, 50 cents per piece being the price paid for the work. After analyzing the job and determining the shortest time required to do each of the elementary operations of which it was composed, and then summing up the total, Mr. Taylor became convinced that it was possible to turn ten pieces a day. To finish the forgings at this rate, however, the machinists were obliged to work at their maximum pace from morning to night, and the lathes were run as fast as the tools would allow, and under a heavy feed.

It will be appreciated that this was a big day's work, for men and machines, when it is understood that it involved removing with a single 16-inch lathe, having two saddles, an average of more than 800 pounds of steel chips in 10 hours. In place of the 50-cent rate that they had been paid before, they were given 35 cents per piece when they

turned them at the speed of ten per day, and when they produced less than ten, they received only 25 cents per piece.

It took considerable trouble to induce the men to turn at this high speed, since they did not at first fully appreciate that it was the intention of the firm to allow them to earn permanently at the rate of $3.50 per day. But from the day they first turned ten pieces to the present time, a period of more than thirteen years, the men who understood their work have scarcely failed a single day to turn at this rate. Throughout that time, until the fall in the scale of wages throughout the entire country, which occurred a few years ago, the rate was not cut. During this whole period the competitors of the company never succeeded in averaging over half of this production per lathe, although they knew and even saw what was being done. They, however, did not allow their men to earn over $2 to $2.50 per day, and so never even approached the maximum output.

The following table will show the economy of paying high wages under the differential rate in doing the above job:

COST OF PRODUCTION PER LATHE PER DAY.

ORDINARY SYSTEM OF PIECE WORK.		DIFFERENTIAL-RATE SYSTEM.	
Man's wages	$2.50	Man's wages	$3.50
Machine cost	3.37	Machine cost	3.37
Total cost per day	$5.87	Total cost per day	$6.87
5 PIECES PRODUCED.		10 PIECES PRODUCED.	
Cost per piece	$1.17	Cost per piece	$0.69

The above result was mostly, though not entirely, due to the differential rate. The superior system of managing all of the small details of the shop counted for considerable.

There has never been a strike by men working under differential rates, although these rates have been applied at the Midvale Steel Works for the past fifteen years, and the steel business has proved during this period the most fruitful field for labor organizations and strikes. And this, notwithstanding the Midvale Company has never prevented its men from joining any labor organization. All of the best men in the company saw clearly that the success of a labor organization meant the lowering of their wages, in order that the inferior men might earn more, and, of course, could not be persuaded to join.

The moral effect of the Taylor piece-rate system on the men is marked. The feeling that substantial justice is being done them renders them, on the whole, much more manly, straightforward, and truthful. A noted French engineer and steel manufacturer, who re-

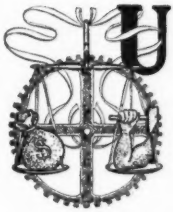
cently spent several weeks in the works of the Midvale Steel Co. in introducing a new branch of manufacture, stated before leaving that the one thing which had impressed him as most unusual and remarkable about the place was the fact that not only the foreman but the workmen were expected to, and did in the main, tell the truth in the case of any blunder or carelessness, even when they had to suffer for it themselves.

In order to maintain harmony between the men and the management, a thorough reorganization of the machinery and tools and the methods of keeping records, as well as of the wages of the men, is often necessary; for that reason it is probable that the general introduction of this or a similar scientific system will be gradual. The chief necessity in practice is not so much the differential rate (although this is very advantageous, especially at the time of introduction), as it is a principle of fixing rates by which the men will know that they are being honestly and fairly dealt with. The whole benefits of the system are destroyed if the men receive the impression that as soon as their output is increased their wages will be reduced.

Piece work has been relegated to constantly repeated operations under exactly similar conditions. Mr. Taylor has shown it capable of wider application; he has shown that it can be employed in the most complicated work and varying conditions. There is a still wider field which is open to this system. In the building trades, lathing is done by the piece, and in engineering construction, sewer-brick laying, and it is a matter of record that an average mason working by the thousand will lay nearly twice as many brick as a man on the roughest kind of a wall above ground when at work by the day. The question arises: If piece-work methods can be satisfactorily employed in molding, chipping, and machining a special casting which is only one pattern of a thousand produced from a foundry, why cannot the principle be applied to various branches of engineering and structural work which are really very much less intricate than the examples of machine-shop practice cited? Sooner or later, our day laborers will be working by the piece, and the hard worker will not receive the same rate of pay per day that is given to the man beside him who shirks whenever possible. Piece work may be started as a result of competition for contracts, on account of the larger amount of work which a man will do when working by the piece; but, if once established, it will be as jealously preserved by the laboring man as by his employer.

THE PREMIUM PLAN OF LABOR REMUNERATION.

By H. M. Norris.



UNDER the terms of the joint agreement entered into between the National Metal Trades Association and the International Association of Machinists, May 18th, 1901, will witness the adoption of a nine-hour working day throughout American machine shops. The question of wages and cost reduction is ever an interesting theme to both manufacturer and workman, but with the approach of this 54-hour-week the problem assumes a phase of almost alarming importance, being no longer a matter of augmenting profits, but of maintaining profits—of gaining for manufacturers and employees in nine hours the same remuneration made formerly in ten.

Mr. O'Connell, the official representative of the International Association of Machinists, makes in his reply to my two former papers on the premium plan this statement: "I have come to the conclusion that a goad is unnecessary to drive the average American workman," but "the time has come when a stimulant would not be an injury." Piece-work he speaks of as an "insidious disease." Its enforcement, he says, "will breed disorder in any shop." The International Association of Machinists is opposed to it, "and will never be a willing party to its propagation."

The *stimulant,* therefore, must come from some other source, since it is through the co-operation of the employees only that satisfactory results are possible.

Imbued, as Mr. O'Connell says he was, with the feeling that if the premium plan "was honestly tried and its promises honestly lived up to, it might prove of great value in reducing the friction that always asserted itself when anything in the nature of piece work was hinted at," it is greatly to be regretted that he was not able to visit the local

The exposition of the premium plan is fittingly placed beside that of the intensified piece-rate system. It is the other great alternative argument, reduced to practical form, offered to the workman in the effort to smooth and make easy the inevitable movement toward paying for production according to the quantity and quality of the product. Mr. Norris, like Mr. Thompson, writes from the standpoint of a practical employer of the system he advocates. Both are leaders who have tested their tactics under fire. Both wear the authority conferred by success.—THE EDITORS.

branches of his association prior to their convention held in Buffalo, New York, in May, 1899, in order that he might lay before them the same evidence of its merits as had caused him to indorse it. For it is under *this system* that "both workman and employer can achieve all their desires without having recourse to any measure that is repulsive to human nature, or disastrous to their mutual interest," and nothing short of ignorance of its principles could have caused its rejection. To understand it is to accept it—not as the best of the bad, but as the best of the best, and once accepted, no man will willingly give it up.

Inasmuch as not all the readers of THE ENGINEERING MAGAZINE may have a perfectly clear understanding of just what the premium plan claims to do for the employer and workman, a brief description of the system may not come amiss. This I will give in the inventor's own words, culling from his "Experience with the Premium Plan of Paying for Labor":

"The premium plan is an application to production of methods long in use in connection with sales. The plan of offering a salesman a salary and a commission is closely analogous to the premium plan, and if for the salary he is expected to sell a certain minimum of goods per annum, the commission applying only to the excess above this minimum, the analogy is exact. Under the premium plan, the workman is paid by the day, and for this daily pay is expected to produce a certain minimum of product, while for an excess beyond that amount he is paid a premium, the amount of this premium being based on the excess and being less per unit of product than the old wages cost.

"Suppose a workman to be paid three dollars per day of ten hours and to produce one piece of a certain kind per day. The wages cost of the product per piece is obviously three dollars. Now, under the premium plan, the proprietor says to the workman: 'If you will reduce the time on that piece, I will pay you a premium of ten cents for each hour by which you reduce the time.' If a reduction of one hour is made, the first result to the employer is to save the wages of thirty cents for the hour which has been saved, but against this is to be placed the ten cents earned as a premium, leaving a net gain of twenty cents to the employer and a net increase of earnings of ten cents to the employee. Had the premium offered been fifteen cents, the result of an hour's reduction of time would have been to save fifteen cents to the employer and to increase the workman's earnings by the same amount. The result of any saving is, therefore, divided between the two, and in a proportion determined by the proportion established between the wages rate and the premium rate. It is obvi-

ous to all, however, that the gain to the employer does not stop here—the gain due to the increased output from a given-sized plant being additional to the immediate cash gain. In the case of large, expensive tools, the gain due to increased output may easily far exceed the gain due to the reduction of wages paid per piece.

"The plan in a sense splits the difference between the day's-work and the piece-work plans. Under the day's-work plan any increase in production by a workman results in an immediate gain to the employer only, the workman getting nothing for his efforts until some time in the indefinite future, when merit, coaxing, cajolery, pulls, or all four together, result in a trifling 'raise' in his wages. Under piece work, on the other hand, an increase in production, after the piece price is once set, results in an immediate gain to the employee only—the employer paying the same wages per unit of production as before, until some time in the future when the workman's earnings have risen to a point where they seem to demand a cut in the piece price.

Passing now from the abstract to the concrete, I show on the next page the front and back of one of our comparative time cards, upon which is given the time consumed on each shop order in performing the several operations on one of our staple articles of manufacture. The columns headed 1, 2, and 3 refer respectively to the lines marked 1, 2, and 3 on the front of the card, and show that the total time consumed in the three operations has been cut from $28 + 86\frac{3}{4} + 33\frac{3}{4}$ to $18 + 48 + 18 = 64\frac{1}{2}$ hours. The time limits on this work were fixed at the completion of the order marked with an asterisk, 27 hours being allowed for boring, 66 for planing, and 27 for drilling and tapping.

If, now, this reduction had been effected under the day's-work plan, it is obvious that the immediate cash gain to us would be—taking the time limits as a basis and figuring wages at 24 cents per hour for boring, 26 cents for planing, and 22 cents for drilling and tapping—$\$.24\ (27 - 18) + \$.26\ (66 - 48) + \$.22\ (27 - 18) = \$8.82$. If, on the other hand, the reduction had been effected under the piece-work system—the piece prices being taken at $27 \times \$.24 = \$6.48$, $66 \times \$.26 = \$17.16$, and $27 \times \$.22 = \$5.94$, respectively—it is equally evident that this additional profit would have gone solely to the workmen. Under the premium plan, however, the immediate cash gain of $8.82 was equally divided between the workmen and ourselves—$\$.12\ (27 - 18) + \$.13\ (66 - 48) + \$.11\ (27 - 18) = \$4.41$ going to the workmen and an equal amount to us.

The saving in time on this job is as 84 is to 120, or as 70 is to 100, and in order to show that cuts of this amount are in no way unusual,

I give, in Table I, the results obtained by one of our employees in 1,770 hours' continuous work under the premium plan, in which it will be noted that the new time is to the old time as 1,770 is to 2,500, or as 70.8 is to 100.

COMPARATIVE TIME CARD.

UNIVERSAL HEAD.

SYMBOL 2M14. TIME ON 6 PCS.

	OPERATIONS	TIME	S. U.	MACH.
1	Boring	27		
2	Planing	66		
3	Drilling and Tapping	27		
4				

REMARKS: Time limit was fixed on completion of Order No. 379.

	ORDER	JOB	1	2	3	4
1	132		28	86¾	33⅝	
2	267		27¼	81	29¼	
3	315		27	69	27	
4	379*		26⅜	63	24⅛	
5	423		22⅛	53	20	
6	576		20	51	19¼	
7	632		19	49⅛	18⅛	
8	1127		18	48	18	
9						
10						

FRONT AND BACK OF COMPARATIVE TIME CARD UNDER THE PREMIUM PLAN OF WORKING.

The data furnished by this table are particularly valuable in that they show, in many cases, the time consumed in performing the identical operation on successive lots of the same piece—ditto marks being used to indicate repetition work. Records 4 to 10, for instance, were all made on the same work, and show how, after the second cut was made, it was some time before the minimum of 18 hours was reached. Attention is also called to item 2, in which it will be noted that the time was cut from 72 to 50½ hours at one leap. Items 19 to 24 are also interesting, as showing the gradual shrinkage from the first drop of 14 hours to the last record of 35 hours.

Taken all together, this table is an excellent example of what may be expected of the premium plan, the records throughout having been

ITEM	NO. PCS IN LOT.	TIME LIMIT.	ACTUAL TIME.	PREMIUM EARNED.	FORMER WAGE COST.	PRESENT WAGE COST.
1	2	20	14.	$ .78	$ 5.20	$ 4 42
2	18	72	50.50	2 80	18.72	15.92
3	18	180	126.75	6.92	46.80	39.88
4	6	30	23.25	.88	7.80	6.92
5	"	"	20.75	1.20	"	6.60
6	"	"	20.50	1.24	"	6.54
7	"	"	20.50	1.24	"	6.54
8	"	"	20.25	1.26	"	6.52
9	"	"	18.	1.56	"	6.24
10	"	"	18.	1.56	"	6.24
11	16	80	58.50	2.80	20 80	18.00
12	"	"	57.25	2.96	"	17.84
13	"	"	52.	3.64	"	17.16
14	6	66	54.	1.56	17.16	15.60
15	"	"	49.	2.21	"	14.95
16	"	"	48.	2.34	"	14.82
17	"	"	48.	2.34	"	14.82
18	6	66	49.	2.21	17.16	14.95
19	6	54	40.	1.82	14.04	12.22
20	"	"	38.	2.08	"	11.96
21	"	"	37.50	2.15	"	11.89
22	"	"	36.	2.34	"	11.70
23	"	"	35.75	2.37	"	11.67
24	"	"	35.	2.47	"	11.57
25	12	144	103.75	5.23	37.44	32.21
26	"	"	103.50	5.26	"	32.18
27	"	"	97.	6.11	"	31.33
28	12	150	102.75	6.14	39.00	32.86
29	"	"	102.	6.25	"	32.75
30	2	26	21.50	.59	6.76	6.17
31	10	105	73.	4.16	27.30	23 14
32	6	21	16.75	.55	5.46	4.91
33	"	"	16.50	.59	"	4.87
34	6	30	23.	.91	7.80	6.89
35	12	66	48.	2.34	17.16	14.82
36	2	30	22.	1.04	7.80	6.76
37	12	39	29.25	1.24	10.14	8.90
38	6	54	40.50	1.76	12.96	11.20
TOTAL.....		2500hrs.	1770 hrs.	$94.93	$650.00	$555.06

TABLE I.—SHOWING THE GAINS IN WAGES EFFECTED IN ACTUAL PRACTICE BY ONE OF THE EMPLOYEES OF THE BICKFORD DRILL & TOOL CO. IN 1,770 HOURS' CONTINUOUS WORK UNDER THE PREMIUM PLAN, TOGETHER WITH THE FORMER AND PRESENT WAGE COST OF THE WORK.

made by the same man on the same tool by the same method under the same conditions.

The greatest amount earned by the workman in excess of his wages during this period of 1,770 hours was made on jobs 9 and 10, the premiums being $1.56 each for 18 hours' work, or 8.66 cents per hour; while the smallest amount earned in excess of his wages during this time was made on job 30, the premium being 59 cents for 21½ hours' work, or 2.74 cents per hour. The average of the whole, however, is 94.93 ÷ 1770 = .0536, or a little over 5 1/3 cents per hour, making a very substantial increase in wages.

Just what effect this reduction in time had upon our profits is not so easily answered. We know, only, that we saved $650.00 — $555.06 = $94.94 in wages on this particular man's work. If, now, we figure general expense at 20 cents per hour, our profits were apparently augmented by the additional saving of $.20 (2500 — 1770) = $146.00. And we must not stop here, for there is the gain due to a more rapid turn-over of our capital, which must also be considered.

Suppose that the 2,500 hours represents the time it consumed originally to build a complete machine, the material for which cost $500. Suppose, further, that the selling price for this tool is $1,980 and that wages and general expense are 26 cents and 20 cents respectively. Our profits then were: $1980 — [2500 ($.26 + $.20) + $500] = $330, or 330 ÷ 2500 = 13.2 cents per hour. Made in 1,770 hours under the premium plan, however, our apparent profits are: $1980 — [1770 ($.26 + $.20) + $.13 (2500 — 1770) + $500] = $570.90, or $570.90 ÷ 1770 = 32.25 cents per hour, or 32.25 — 13.2 = 19.05 cents per hour greater than when the work was done under the day's-work plan.

Figured on this basis, a reduction in time by one-half results in an increase in profits of from 30 to 35 cents per hour, according to the rate of wages paid the workmen. For example, if the cost and selling price of a piece of work requiring originally 60 hours to construct were equal, a reduction in time by one-half effected by a 20-cents-per-hour workman would result in a gain to the manufacturer, under the premium plan, of 30 cents per hour. Likewise, a cut of 30 hours by a 30-cents-per-hour workman would mean an increase in profits of 35 cents per hour, the gains per hour increasing with every change of rate in wages, as shown by Table II., on the next page.

We all know, however, that with every increase in production comes a corresponding increase in expense, each augmentation in output requiring more motive power, more inspectors, and more laborers,

TIME CONSUMED.	RATES OF WAGES					
	·20	·22	·24	·26	·28	·30
60	.0000	.0000	.0000	.0000	.0000	.0000
54	.3333	.0344	.0355	.0366	.0377	.0388
48	.0750	.0775	.0800	.0825	.0850	.0875
42	.1286	.1328	.1371	.1414	.1457	.1500
36	.2000	.2067	.2133	.2200	.2267	.2333
30	.3000	.3100	.3200	.3300	.3400	.3500

TABLE II.—SHOWING HOW PROFITS INCREASE UNDER THE PREMIUM PLAN AT DIFFERENT RATES OF WAGES, AS THE TIME CONSUMED ON WORK IS REDUCED FROM 60 TO 30 HOURS.

to say nothing of the losses due to the additional wear and tear on plant, the greater consumption of supplies, and the occasional re-working in one department of work that has been more or less slighted in some other, which items, although comparatively small in themselves, mount up in the aggregate to a considerable sum.

Two fundamental questions which must be settled before the system is put into operation are, on what basis shall the time limit be set, and what percentage of the saving shall be given to the workman? On these points Mr. Halsey says: "One method—and the wrong one—is to take the best record obtainable as a base, and then offer a liberal premium for its reduction. * * * I have adopted the settled policy of being liberal with the time rate, rather than the premium rate. * * * I am now satisfied that the principal danger to the success of the plan lies in the tendency to adopt the opposite course. At first the proprietor is disposed to be liberal, and expecting a small increase only, he offers large premiums. The premiums should at the start be too small rather than too large. If found too small, they can be raised, but if too large, they cannot be cut without destroying the confidence of the workmen in the system and in their employers' intentions. It must be remembered that in a large proportion of machine-shop work, increased production calls for little or no increase of labor on the part of the workman. It is in such cases more a matter of using his wits than his muscles. In other words, he crowds the machine rather than himself. * * All experience, however, shows that the increase of output will be far more than anyone expects, and the premium rate should be decided with that point in mind. A practical way of looking at the matter is to assume the output to be doubled, as the extreme possible, and then to decide how much the shop can afford to raise pay to secure such an increase. * * * It will be seen that a large element of judgment must enter the

administration of the system. I am in fact fully convinced that the system puts a sharper test on the capacity of the management than it does on that of the workmen, and this fact will determine the limits of its application."

For the average shop, changing from the usual lax method of the day's-work plan to the premium plan, I believe Mr. Halsey's policy of liberality with the time rate rather than the premium rate is the correct one; but where a shop has already been placed on an efficient basis, I feel that there are frequently conditions which warrant the management in adopting the opposite course. In the works of The Bickford Drill & Tool Company I have made it the practice to fix the time limit at what seemed a fair day's work for the average machinist, and to divide wages equally on all time saved on this limit. I consider that the chief gain to us comes from the increased output, rather than from the reduced wages per piece, and that if the time limits are fixed with proper precaution, the general results are more beneficial than where the limits are high and the rates low. I have, it seems to me, two good reasons for adopting this course. The first is that it fixes a higher standard of efficiency for the workmen—each being required to produce a minimum of so much work per hour in return for his regular wages. Time is the all-important factor, and unless kept down, profits soon vanish. Suppose, for instance, that 10 hours represents a fair allowance for a certain piece of work, the selling price of which is $6, our profits are obviously $6 - 10 ($.30 + $.20) = $1, or 10 cents per hour. If, now, we permit some other workman to spend 12 hours on the job, the result is a direct loss of 2 ($.10 + $.30 + $.20) = $1.20, showing that it is the rapid men only that we can afford to keep. I believe, therefore, that for the average shop, operating on a narrow margin of profit, that plan is the best which most quickly weeds out the slow workmen. And this is equally true of the day's-work plan. Wherever competition is sharp between manufacturers, prices fall with increased production, and there must be no slipping back. To avoid this it has long been my custom to place limits on all our work, not only as an aid to the cost clerk in detecting any falling behind in our output, but in order that wages might be graded according to the individual ability of the workmen. Where one man receives 30 cents per hour for performing certain work in 17 hours, I felt that another workman taking 20 hours for the same operation received as much as he was entitled to if we paid him [17 ($.30 + $.20) — (20 × $.20)] ÷ 20 = 22½ cents per hour—this being the maximum rate we could give him without cutting into our profits.

My second reason for using lower time limits and higher premium rates than recommended by Mr. Halsey is that I believe that after a workman has made his first cut he has less incentive to effect further reductions if each saving brings him, for instance, an increase of only a quarter of his wages instead of a half. The first cut is usually accomplished with very little additional exertion on the part of the workman, but after that increased production is apt to call for increased muscular labor, as well as an increased tax upon the mind, and should, I feel, be rewarded with the higher rate of premium.

I do not wish to be understood, however, as recommending the adoption of this higher rate for the average shop, for I am sure that it would sooner or later cause the downfall of the system. Human nature is the same the world over, and while a manufacturer may console himself for a time with the thought that every additional cent earned by the workman means one, two, or three cents saved to him, there will come a time when he will feel that he was imposed upon at

ORDER NUMBER.	NO. PIECES IN LOT.	TIME CONSUMED.	WAGES PER DAY.	COST PER PIECE.
374	6	78	$2.00	$5.20
489	6	62	2.00	4.13
524	6	56¼	2.00	3.75
769	6	54½	2.00	3.63
943	6	42¾	2.00	2.85
1128	6	40¾	2.00	2.72
1331	6	38¾	2.00	2.58
1569	6	18½	3.16	1.59
1698	6	19	3.10	1.62
1747	6	18	3.22	1.57

TABLE III.—SHOWING THE GREATEST REDUCTION IN TIME THAT HAS BEEN EFFECTED UNDER THE PREMIUM PLAN AT THE WORKS OF THE BICKFORD DRILL & TOOL CO.

the start—that the men were previously laggards—and that now they are getting much more than they deserve; then follows a cut, and with it comes the disruption of the system.

In order to present as clearly as possible the danger of adopting too high a premium rate, I give, in Table III, the actual records made in machining ten successive lots of a certain piece of work. It so happened that this job was not offered under the premium plan until the completion of order No. 1331, when the limit was fixed at 40 hours. From a best previous record of 38¾ hours, the time is reduced to 18½ hours in the first cut, and from that finally to 18 hours. Suppose, now, that we had had occasion to fix the limit at the commencement of order No. 769. It is possible that we would have allowed 60

hours for the work, in which case the workman's last earnings—under a quarter-wage rate, his wages being 20 cents per hour—would have been $3.16 per day, while his last earnings under a half-wage rate would have reached $4.33 per day—showing how rapidly wages advance under the higher rate of premium.*

Just one thing more. In no case yet where the plan has been introduced have the employees received it with any feeling other than of suspicion. They appear to regard it as the entering wedge to piece work. Any management installing it must, therefore, expect to meet with considerable opposition at the start, but "even from this point of view," says Mr. Halsey, "the system has decided advantages in that it does not involve compulsion. * * * In the shops where the plan has passed the trial stage, it is uniformly popular with the men—indeed, a plan which deliberately sets out to increase wages can hardly be otherwise than popular when it is once understood, and it is the uniform experience that after the workings of the plan have been shown there is a steady call from the shop for more work to be given out on premiums."

It is obvious that increased earnings can be made only through the reduction of costs. This the premium plan secures, bringing it within the pale of the strictest principles of economics. Were it otherwise, it could never have stood the test of the sixteen years that have elapsed since the date of its inception. What the workman desires is high wages per day, and what the manufacturer must have is low cost per piece, both of which needs the premium plan meets—equitably, harmoniously, automatically—and in a way that introduces a spirit of co-operation which goes further toward settling the wage problem than anything else that has been suggested. There is no goading or whip-cracking, no threats, fines, or punishments, no herding together at so much per head. Instead of being held down to "the average wage paid in his locality," the workman preserves his individuality. He is given an opportunity to profit by his industry. He is raised from a mere automaton to a man, alive to the possibilities of bettering his condition—an intelligent worker, certain of receiving a just share of his employer's profit. Is it not clear—can it not be made clear?—that here is the path to the goal that both parties have striven so long to reach—high wages and low cost.

* This work, prior to being given out under the premium plan, was done in two operations. The workman first machined all the pieces in the lot, and then babbitted them. Encouraged by the certainty of reward for his extra exertion, he afterward combined the two, doing his babbitting on one piece while his machine was engaged on the next, thereby effecting the tremendous saving shown.

A SURVEY OF MODERN FOUNDRY PRACTICE.

By Percy Longmuir

A FOUNDRY, be it iron, steel, or brass, of any large establishment, is almost always looked upon and treated as the necessary evil of the concern. Pounds upon pounds are spent on up-to-date machinery and modern labour-saving devices of all kinds, for the pattern-making, machine-tool, and kindred departments. The heating, ventilating, and lighting arrangements of these departments are generally of a fair order, and under these conditions the occupants naturally present a much smarter and more "go ahead" appearance than do their "brother smuts" of the foundry. When the question of a similar equipment for the foundry arises, long tales, not of woe, but of working and other expenses are unfolded, and as for heating a foundry during the cold of winter—whoever heard of that? Certainly if the weather be extra cold the moulders are allowed to light a few kettles or "devils" and spread them over the shop, filling it with the smoke and fumes supposed to be so dear to the heart of a foundryman. But for actual heating appliances, where are the British foundries so fitted? And as for sanitary or lavatory accommodation, the foundries of Great Britain will not compare with those of the cousins over the water.

But I do not thus disparage all British foundries, having had experience in a few which might be termed "model foundries," and my recollections of these establishments are always pleasant. In them the men were of much higher calibre than is generally the case, the conditions favoured the production of good work, and the general atmosphere was one likely to develop and utilise the latent powers of each individual. Such a feeling is well worth encouraging, and if it can

Mr. Longmuir's arraignment of foundry practice for its relative backwardness, though directed first against British works, has quite too-general appropriateness everywhere. The few establishments which have treated this department with the same progressiveness and broad understanding of economy which pervade their machine shop or their power plant, stand out as shining examples—but not always as widely useful examples, as they are not in all cases willing to be studied in this regard, desiring rather to hide their light from the public eye.

The notable examples from which the illustrations of this paper are drawn show how much can be done to bring up the efficiency of the foundry and the standing of the foundry worker to the level of the machine shop. The field is one which will amply repay study and interchange of experience. A free exposition of it will be generally beneficial, and THE ENGINEERING MAGAZINE will welcome to its pages the discussion of problems of foundry practice.—THE EDITORS.

be brought about by the investment of a few pounds in making our foundries more congenial, surely the money is well spent, whilst the return is almost sure. Progress is all the cry nowadays, but on looking over the record of foundry work for the last few years, what real advance may be noted? We have newer types of cranes, electric and hydraulic, and more efficient varieties of moulding machines. The chief advance in furnace construction lies with the steel founders. An American open-hearth furnace of to-day, with its mechanical charging apparatus and fittings, cannot be otherwise described than as "up-to-date." It is in the general foundries, not having many specialties to encourage the fitting up of special plant and tools, that the least advances have been made. This is to be expected, and it does indeed seem a hard matter, with constantly changing work, to devise plant that shall meet these changes and yet be ever of the latest type. The purposes of this article, therefore, are to give a rough indication of the present condition of foundry matters and the lines on which a possible advance may be made.

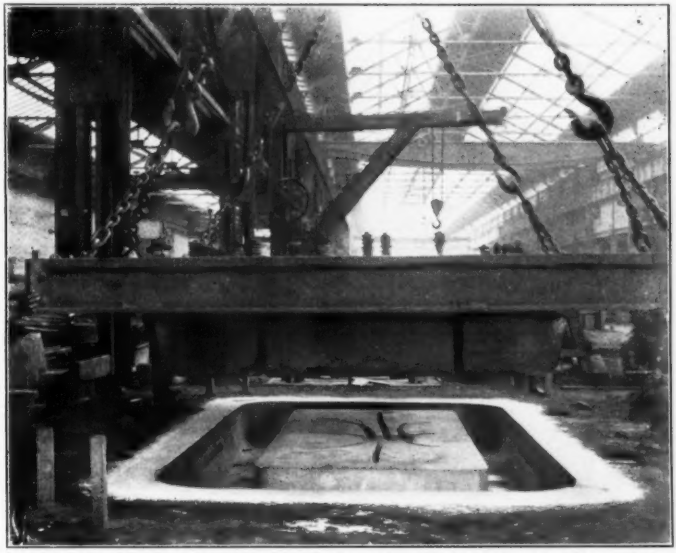
In many respects the jobbing foundries of yesterday differ but little in the matter of tools and method from those of to-day. The cupola, generally an old funnel or boiler shell lined up and seldom possessing more than two tuyeres, gave fair results and the fuel ratio was not greatly in excess of that of modern ones. They were efficient tools and gave hot metal of a fairly uniform composition at a fairly quick rate. Brass-melting furnaces were the familiar crucible and reverberatory, natural draught in each case being employed. Steel castings are of a comparatively recent date, but the earlier ones were all cast from metal melted in crucible furnaces.

General moulding appliances have not undergone much development. Boxes and moulding tools are the same, as well as the lifting tackle, slings, beams, crosses, etc. Therefore, although the founder of old had much against him, he was in many respects no worse off than his modern brother. He had the further advantages of a less-keen competition and specifications of a much more lenient nature than those we have to meet.

Chemical analysis did not in the early days play a very important part in foundry work. The purchase and grading of pig iron by fracture only resulted in a school of men remarkably expert in judging and reading these fractures. But the fracture of a pig iron, as every founder will admit, is affected by the initial temperature and also by the rates of casting and cooling. The deceptiveness of a fracture and the many failures resulting from such judgment turn us toward chem-

ical analysis, and the modern founder will grade and purchase his iron only on the result of such analysis.

In the steel foundry analysis is a recognized institution, and the day is fast approaching when such will be the case with the iron and brass foundry. The various kinds of metal will be judged and graded by analysis, chemical and mechanical only. The sulphur and ash of a coke will be estimated, the alkalies of refractory materials determined, and the amounts of these elements present will give the founder definite data as to their value and the extent to which they may be used.



JIB CRANE LIFTING COPE ONTO HEAVY SWEPT MOULD, GENERAL ELECTRIC COMPANY'S FOUNDRY.

There has been a great advance in the requirements castings have to meet. The high-speed engine and high-pressure boiler are responsible for this advance, and the specifications for the castings required in the construction of these engines and boilers are necessarily of a somewhat stringent character. In tenacity, average gun metal has to show an ultimate breaking load of from 12 to 14 tons per square inch and an extension of 8 per cent. on a 2-inch length. The requirements of bronzes vary, but the average is about 17 tons per square inch in tenacity with an extension of 15 per cent. on a 6-inch length. Bars 1 inch diameter by 8 inches long are expected to bend parallel over a 2-inch radius. Steel castings are required to show a tenacity of 28 tons

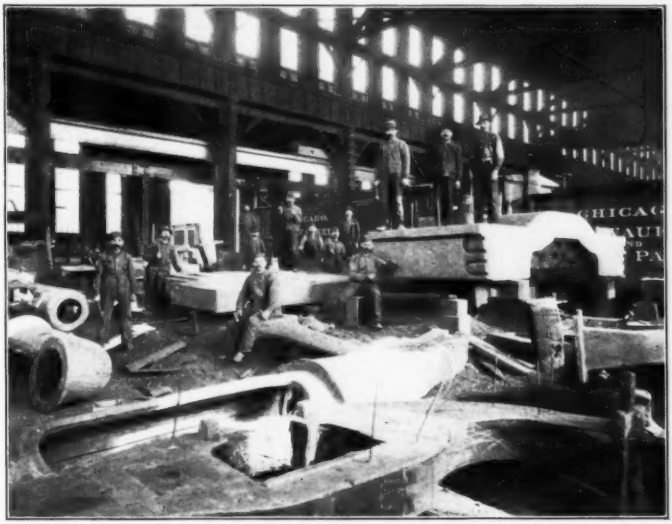
per square inch with an extension of 13 per cent. on a 2-inch length. Bars for bending tests have to bend through an angle of 90°. Cast iron is required to show a tenacity of 10 or 11 tons per square inch. In the transverse test a bar 2 inches by 1 inch, supported on centres 3 feet, must carry a load of 30 hundred weight on section before breaking. In addition to these mechanical tests, castings for steam or water pressure have hydraulic and steam trials at much higher pressures than those at which they are expected to work.

To enumerate under separate headings all the work of an iron, steel, or brass foundry would be beyond the scope of this paper: therefore only an outline will be attempted. Starting with the iron foundry, it would indeed be a hard matter to say what the work of such an establishment does not comprise. A rough grouping would give us foundries engaged on engine, marine, and jobbing work, and also the specialty shop. The latter—that is, the foundry devoted exclusively to one class of work—is the one which pays, and with proper management pays right royally. In it we can put the latest and most efficient plant; special tackle can be designed for repeat work, which will materially help to lessen the cost of production. Plant of this kind once installed can be used to advantage and made to give a good return on its outlay. This is by no means the case in the engine or marine foundry. Here the work is constantly changing, little or none of it being standard, and as a result the plant and tools are designed to be of a general rather than a special use. In itself this is crippling, and the character of the work prevents the greater adoption of labour-saving devices. The marine foundry offers many fine examples of the moulder's art, for so it may be termed, and the mention of cylinders, condensers, propellers, and the like convinces us that the moulder's trade, if not an art, is at any rate one of the most difficult of all trades associated with engineering practice. The engine foundry has in many respects a class of work similar to that of the marine.

Reference has already been made to hydraulic testing, and the iron foundry meets with its share of wasters from this test. Cylinder covers give trouble—though, often as not, faulty design is the cause of porosity. Valve bodies are often inclined to leak round the seat facing, which, by the way, is the thickest part of the casting, or round the junction of the flange and body. The flange itself may be porous and the body of the valve tight, as shown when the water percolates through one of the stud holes. To overcome these difficulties some knowledge must be attained of the work and the mixture of iron arranged to meet these requirements.

These requirements vary, but the varieties of pig and scrap in the mixture must be apportioned to give the result individual experience would indicate to be the best. A further point is the temperature of casting, and here again individual experience must be the guide.

The work of a jobbing foundry is, to say the least of it, varied. Castings may be made in it ranging upwards from sash-weights and open sand plates to engine-bed plates and cylinders. Loam, dry sand and green sand may be in progress all at the one time and in various parts of the shop. The appearance of such a concern, to an outside eye, would be one of hopeless chaos. Nevertheless very fair castings are made in these establishments, and undoubtedly they are the best training ground for our moulders, for the experience gained in them is both varied and extensive.



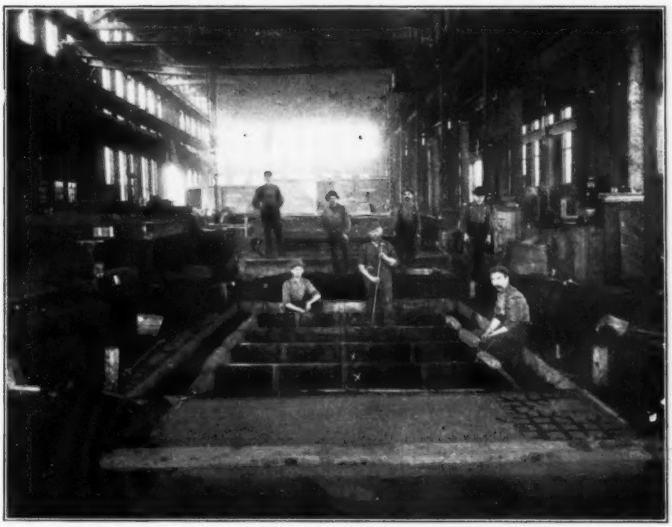
CHIPPING ROOM, E. P. ALLIS COMPANY'S FOUNDRY, SHOWING THE HEAVY ENGINE WORK TURNED OUT.

The work of a brass foundry varies according to environment; it may be a specialty shop engaged on valves only, possibly on one type of engine work, or it may be doing general engineering castings. The variety of work in the latter establishment may be gathered from the fact that the metals used range from copper to aluminum, the alloys include various qualities of brasses, gun metals, bronzes, and white metals. The bearing brasses made in this establishment range in size from those required by the shafts of a large battle-ship down to the

main bearings of a small fan engine. A rough survey of the articles made by an engineering brass foundry would include condenser castings, stern tubes, shaft liners, propellers, bosses and blades, stem and stern-post fittings of a cruiser, engine, boiler, and ship's mountings, and the brass castings required by the electrical and plumbing departments.

The high initial melting point of steel, its liability to occlusion, and the high contraction coefficient, render extreme care necessary in manipulating the metal or in making the mould. The moulds vary from stern posts and pump rods upwards of 40 feet in length down to the small fittings required in the construction of a bicycle. Many engine details are cast in steel; these include pistons, cross-heads, eccentric straps, main bearings, and cylinder covers. Bed frames and columns for the marine engine are cast in the steel foundry. Spur and bevel gearing of all types is made in varying sizes. Small castings for high-class bicycle and motor-car details are made in steel. For average work, similar castings are made in malleable iron. Dead mild steel castings for electrical purposes are in an increasing demand, and if steels of greater magnetic permeability can be commercially produced this field of work will be an expanding one. Steel castings hav-

FOUNDRY OF THE E. P. ALLIS CO., MILWAUKEE, U. S. A. MOULD FOR 24-FOOT ROPE WHEEL IN FOREGROUND.



MOULDING BED-PLATE FOR 6,000-HORSE-POWER ENGINE, FOUNDRY OF THE E. P. ALLIS COMPANY.

ing a water test to meet comprise hydraulic cylinders, tees, pipes, bends, stop valves, and boiler connections. As is the case with cast iron and brass, many failures on this test are due to faulty or ill-proportioned design. Apart from errors of moulding or melting, there are severe contraction strains which in not a few cases are responsible for the leakage of castings. Many forms of steel castings are liable to warp, technically known as "pulling." A casting so distorted gives not a little trouble in "setting," and much of this work can be saved if the patterns are set out of truth to the extent of the "pull." This can only be accurately done by working on the result of many observations of warping and contraction. In some cases steel castings seem to vary in their warping tendencies for mere "cussedness," and therefore a fixed rule that would meet the majority of cases can not be laid down. As is well-known, all steel castings require a subsequent annealing. Much of the after success of the casting depends upon the thoroughness of this annealing.

The material of which a mould is constructed must allow the free passage of air and gases generated at the moment of casting. It must be firm, and sufficiently compact to withstand the pressure of the liquid metal. It should be capable of withstanding the high temperature

without fusing, and be readily removed from the casting, to which it should give a clean, smooth skin.

Moulding sands consist essentially of silica, with more or less magnesia, alumina, lime, and certain metallic oxides. The presence of these metallic oxides and lime, if in excess, seriously impairs the refractory qualities of the sand. Magnesia and alumina act as binders, silica increases the refractory qualities, but when in excess does so at the expense of plasticity.

The quality of a loam varies with the locality, and in addition to this most foundrymen have a pet theory of their own in mixing up loam. It is, or should be, specially ground for each particular class of work, and consists of various qualities of sands ground to the required consistency under edge runners. To this are added varying amounts of either hair, hayseeds, or dung. The best loam, and one that rarely "scabs," is made from sharp sand and clay, the latter being added in sufficient quantity to give the requisite cohesion to the loam. It is ground in the usual fashion under edge runners.

The mould for a steel casting, owing to the high melting point of this metal, must of necessity be of a very refractory nature. To meet this, silica sands in conjunction with binding materials are used. There are many compositions technically known as "comps" in use. These consist of old clay crucibles, fire-brick, or similar refractory material, ground to the required fineness and mixed with various binding agents.

Whilst on the question of sands it may be well to state that a mould for brass or gun-metal should be in a much dryer condition than one for iron. An iron-founder's sands may be coarser and his moulds more moist than a brass founder's, for the reason that the heat-conducting powers of iron are much less than those of the copper alloys.

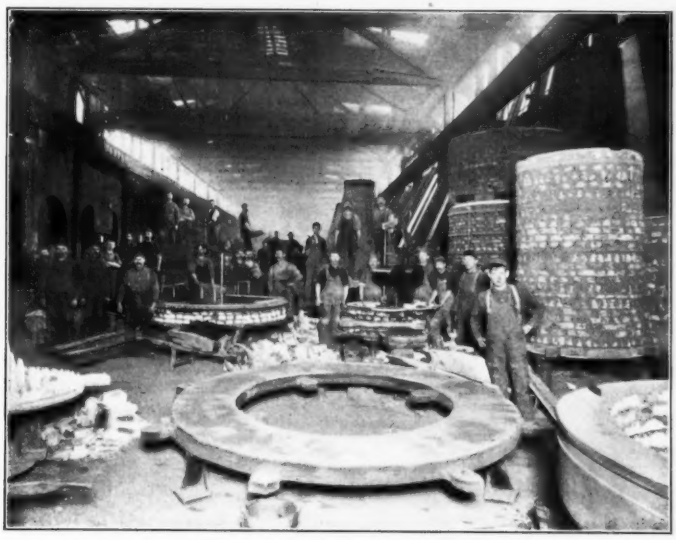
From a consideration of the sands we come to the crucial question of their use and of the appliances that facilitate this use. Many methods have been devised to increase the turn-out of a foundry, especially so with light repetition work. In much of this class of work the only way in which a fair profit can be made is by the most minute attention to detail. It is not a question of hours, but rather of saving minutes, and often on a large order the minutes so saved turn the scale between profit and loss. It therefore behooves foundrymen to give this question of minutes the greatest attention, and any contrivance that will lessen the cost of production, even though trifling, should be adopted. But it must be remembered that the aim of any such contrivance is to lessen nett cost, and not, as do so many system plans and

machines lately brought forward, actually *increase* nett foundry cost of production.

All patterns should be finished as well as circumstances will allow, suitably halved, and all loose pieces dovetailed on. The pattern, when it leaves the pattern maker's hands, ought to be complete, no corners, fillers, or the like left to the moulder to cut, for when the moulder has these alterations to make they are apt to look clumsy and be irregular. After each day's work is put down the patterns can be polished with bees' wax or similar material. This plan is followed in many malleable-iron foundries, and it lengthens the life of the pattern in addition to keeping it in good working trim.

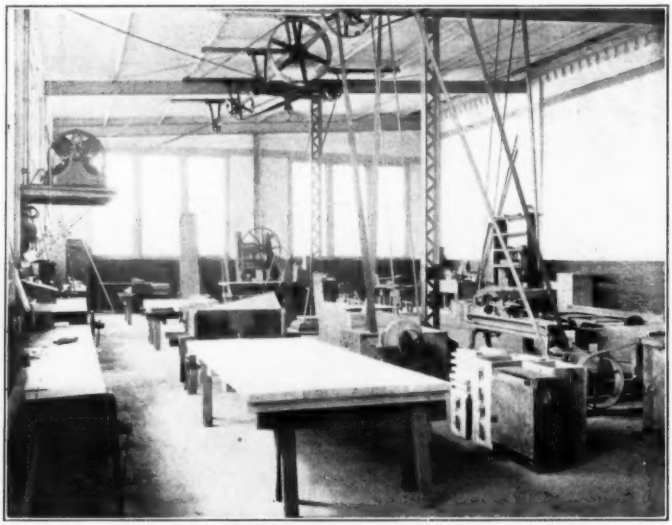
The moulding boxes for small castings should be fairly light, easy to handle, and members of each size should be interchangeable one with another. Joint faces are planed or milled true, whilst the pins are either tapped into the snug or turned with a shoulder and fixed by a nut below the snug. Rivetted pins are apt to work loose and a loose pin, to the founder, should be *"un bête noir."*

In many foundries valuable time is lost in searching for material, tools, etc. The best that can be said for such a condition is that it shows a lack of organisation. Every box ought to have its fittings complete, bottom boards or plates, if used, runner cups, weights, etc.



LOAM MOULDS, E. P. ALLIS FOUNDRY.

A suitable form of weight covers the whole of the box, the recess taking the runner. It prevents any straining or "run outs." Each moulder ought to be fitted up with his own tools, as shovel, rammers, sieves, brushes, and bellows. Further than this, he should be held responsible for their proper use and safe keeping.



FLASK ROOM, GENERAL ELECTRIC COMPANY'S FOUNDRY, SCHENECTADY, N. Y.

"Oddside" moulding is largely practised in brass and malleable-iron foundries. The oddside may be of sand, where only a few boxes have to be made with it, or, in the case of larger orders, it may be of plaster, cement, or any of the compounds specially prepared for this purpose. Its object is to save making a joint each time of moulding. In many cases the quantity of castings required will warrant the casting of a full set of patterns with runner attached. This, if nicely finished off, will hasten the operation of moulding, as the whole set of patterns are in one and, if the oddside gives clear joints, little or no tool work is necessary in finishing the mould. Even when the patterns are worked loose it is advantageous to have a gate or "runner" pattern. These runners, arranged to suit the job, save the moulder trouble and ensure a gate of the right size in each casting.

Plates for plate moulding are of two types—plate and pattern cast all in one piece, or the patterns suitably divided are mounted on a planed plate. The latter is perhaps the better plan, for by it the half-

patterns can be machined up true. It is a fairly easy matter to mount them, with runners to correspond, on the flat plate. With a cast plate very little machining can be done; consequently all the finishing is hand work—a rather expensive operation. Plates may be fitted up entirely of wood, though at the best this is but a primitive method and one not to be recommended. Both plate and oddside moulding permit the use of snap flasks. Adjustable pins allow for wear and are always worked to give a true fit. When the completed mould is put down for casting the flask is unhinged and lifted away, in one sense acting as a core box, the mould being the core. Weights used for "snap" work must cover the whole of the sand, and for deep castings having a tendency to burst the mould, binders should be used. These binders are of light cast or sheet iron and are rammed up with the snap. They keep the sand firm against a side-pressure and hence their use for deep work. The ends of the rammer may be protected with a face of light iron, or they may be tipped with hide—preferably the latter. For cleaning loose sand from the moulds, flexible pipes attached to a blast main or compressed-air supply are handier and more efficient than bellows.

The introduction of mechanical appliances for moulding has in many cases met with great success, notably in specialty work, as gearing of all kinds, or machine and other castings in which there is a demand for standard sizes. The castings required in the construction of sewing machines offer special advantages to the introduction of mechanical work—advantages which are realised to the full extent by few firms in Great Britain. Many useful hand-moulding machines are to be had—though "machine" in its full sense is hardly a correct term, for the only mechanical function is that of drawing the pattern plate from the mould. Stripping plates, if used, ensure a clean part and give a mould with no broken edges. With certain of these machines loose patterns can be arranged on an oddside, and in the case of small orders thus save the expense of a pattern plate. Drawing a pattern through a stripping plate is a simple operation, hence the introduction of an inexpensive class of trained labourers in place of moulders to operate them. The ramming, venting, and finishing of a mould is practically the same with hand-machine as hand-plate moulding, a fact often overlooked by the advocates of this class of machine moulding. The prime movers in use for operating moulding machines comprise hydraulic, pneumatic, and steam powers. Good results have been obtained with hydraulic power, and machines so operated have been installed with more or less success in many engineering and specialty foundries. Power machines are made to take a standard-size

box, or if not, the box is part and parcel of the machine, and the mould, when completed, is pushed up through the box by means of an inner ram. In this case bottom plates and binders are required, the former of cast iron for lifting away the mould, and the latter of light cast or sheet iron to sustain the mould against the casting pressure. A moulding machine to be really successful must be specially designed for the

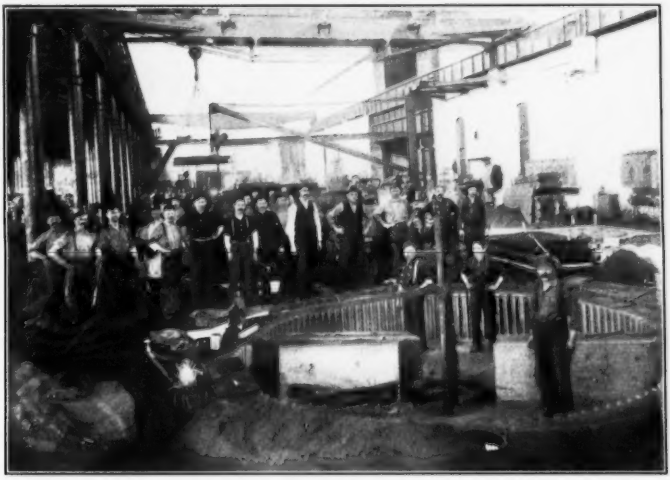
SWEEPING A MOULD FOR A HEAVY FLYWHEEL, FRASER & CHALMERS FOUNDRY, CHICAGO, U. S. A.

castings it is intended to produce, and, further, it must be kept on this particular class of work only. The failure and consequent condemnation of many machines is due to the view that works managers—whose knowledge of foundry matters is as a rule limited—have taken that such tools are universal. This is absolutely the last sense in which a moulding machine should be regarded.

In sand moulding much can be done independently of machines to cheapen cost of production and facilitate the turn-out. Many castings made in dry sand could with the introduction of suitable cores be made in green sand, often resulting in a saving of pattern making as well. On the other hand, many castings made in green sand would, if dried, be made much cheaper. A strong factor in favour of dry-sand work is that the risk, always a very present element in the foundry, is con-

siderably diminished. Pattern making in the case of circular or semi-circular castings can to a certain extent be saved by the use of sweeps and strickles. A familiar case is that of a fly-wheel, the rim of which is swept up in sand whilst the hub and arms are formed with cores. A covering cope is swept from the same centre. Spur wheels are made in a similar way, segment cores forming the teeth. An extension of this principle is the wheel-moulding machine, which may be of a portable or fixed design. A method of core making often adopted with elbows and pipes of irregular form is to make the core in the mould by thicknessing it—that is, by laying on strips of clay of the same thickness as that required in the casting. The two halves of the mould form the core box; suitable grids are used so that the two half cores, when dry, may be bolted together. The plan will admit of extension, and in cases where only single castings are required will save the expense of core boxes.

Loam moulds can in certain cases be made to serve several times



SEGMENT-MOULDING OF LARGE GEAR WHEEL, FRASER & CHALMERS FOUNDRY, CHICAGO, U. S. A.

of casting, a good example being that of a propeller blade. After the first casting the bed is set in exactly the same position as that in which it was built, and swept; this is fairly easy to do, as the gables are not disturbed until the order is completed. The skin of the mould is broken and a thickness of facing loam swept over; on this the pattern is formed as usual with guide strips. A thickness of facing loam

DRYING MOULDS AND COPE IN POSITION BY PORTABLE ELECTRIC FAN AND BLAST HEATING STOVE, GENERAL ELECTRIC COMPANY'S FOUNDRY.

is spread over this, and the cope, which has previously had the old skin scratched away and has been given a coating of clay water, is bedded on. A similar plan is adopted with many loam castings of a simple character, and moulds for pans, kettles, etc., are often used over.

Several types of heaters are in use for drying or skin-drying sand moulds by means of hot air. Foundry drying stoves are not always the efficient tools they should be. In many cases the carriages take far too much moving, and when they do move shake the moulds far more than is good for them. Many stoves have too much waste space, and the walls and roof are too lightly built, resulting in a loss of heat by radiation. The ideal stove should be just large enough to take the loaded carriages. These carriages should run easily on well-laid tracks and offer little vibration. The firing arrangements should be such that all the heat of the fuel, whether coal, coke, or producer gas, is utilised.

A brief survey only will be attempted of the various types of furnaces used by the founder. As a rule the methods of working furnaces vary as much as the types, and hence the reason of so many old home-made furnaces giving results equal to, in many cases, some of the most

up-to-date ones. The success of a furnace lies more with the way it is worked than in design, and the best results can only be obtained by proper working and efficient management. It is a problem of no little interest as to what constitutes "proper working" and the standard by which the work of a furnace should be judged. In this respect three factors are important.

1:—Fuel consumption.

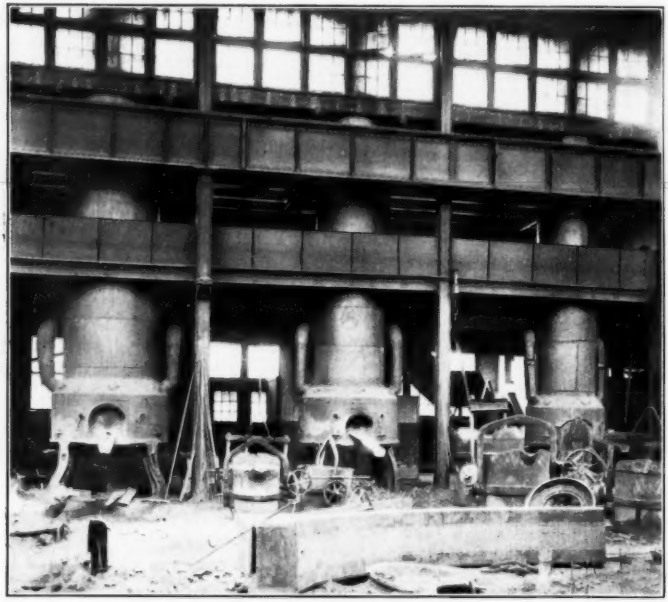
2:—Life of the furnace.

3:—Condition of metal obtained from the furnace. Many works managers unacquainted with foundry work attach far too much importance to the first condition, while the third, and from the founder's point of view the most important, is ignored. Low fuel ratios look well on paper or in the circulars of a furnace builder, but the question to the founder is how far are they really economical. Dull iron in many cases means a dirty casting, whilst dull brass or bronze may result in a drawn or porous casting. Not a few wasters may be traced to being cast at too low a temperature. These wasters, in addition to the actual loss of the casting, have a demoralising effect on the moulders and tend to develop a "don't care" method of working. It will

INTERIOR OF THE DEERING HARVESTER COMPANY'S FOUNDRY, CHICAGO, ILL., SHOWING REPETITIVE WORK.

readily be seen then that the fuel ratio of any furnace should be taken as that required to bring the metal to the best condition for casting, and not that required just to melt the metal. This ratio will vary with similar furnaces in different foundries and with different classes of work.

The cupola may be described as a cylindrical shaft furnace. It possesses one, or, in later types, two rows of tuyeres, which are supplied with low-pressure blast at or about atmospheric temperature. The blast is furnished by a fan or, more generally, by a blower of the Root's type. The charges of coke and iron are carried up to the charging stage by means of a lift, which is most conveniently operated by hydraulic power. The metal, as it melts, collects in the bottom of

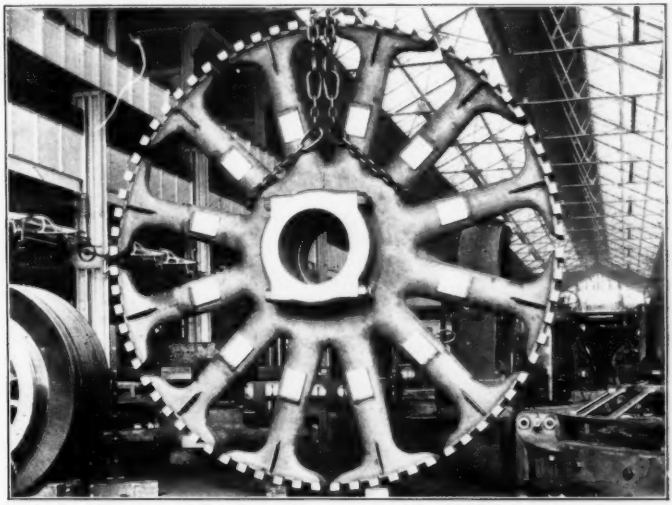


CUPOLAS, GENERAL ELECTRIC FOUNDRY.

the cupola and is tapped out at intervals, or it may be gathered in a receiver. All present day cupolas are, or should be, fitted with "drop bottoms," the utility of which any founder will recognise. The blast main should be fitted with a pressure gauge, which will assist the furnaceman in keeping his working conditions as uniform as possible.

Limestone is generally used as a flux in the cupola furnace. It

fluxes off the silica of the sand adhering to the pig iron and scrap. It also takes up any silica produced by oxidation of the silicon in the iron and combines with the ash of the coke. Latterly fluor-spar has been used with good results, and a combination of fluor and limestone is used in many foundries with excellent results. The effect of remelting iron in the cupola is, in foundry parlance, "to harden it." If the



DIFFICULT CASTING FROM THE GENERAL ELECTRIC COMPANY'S FOUNDRY—THE SPIDER OF A LARGE ARMATURE.

original iron is soft, by remelting it becomes harder and closer in grain and it may be stronger. On remelting hard cast iron, the hardness is still further increased and loss of strength the result. The physical changes brought about by remelting cast iron are indications of chemical changes in the material, which vary according to the amount of oxidation it has undergone. These changes are shown in the following table by Jüngst, of the Imperial Foundry, Gleiwitz:

	1st melt.	2d melt.	3d melt.
Graphite	2.73	2.54	2.08
Combined Carbon	0.66	0.80	1.28
Silicon	2.42	1.88	1.16
Sulphur	0.04	0.10	0.20
Phosphorus	0.31	0.38	0.28
Manganese	1.09	0.44	0.36

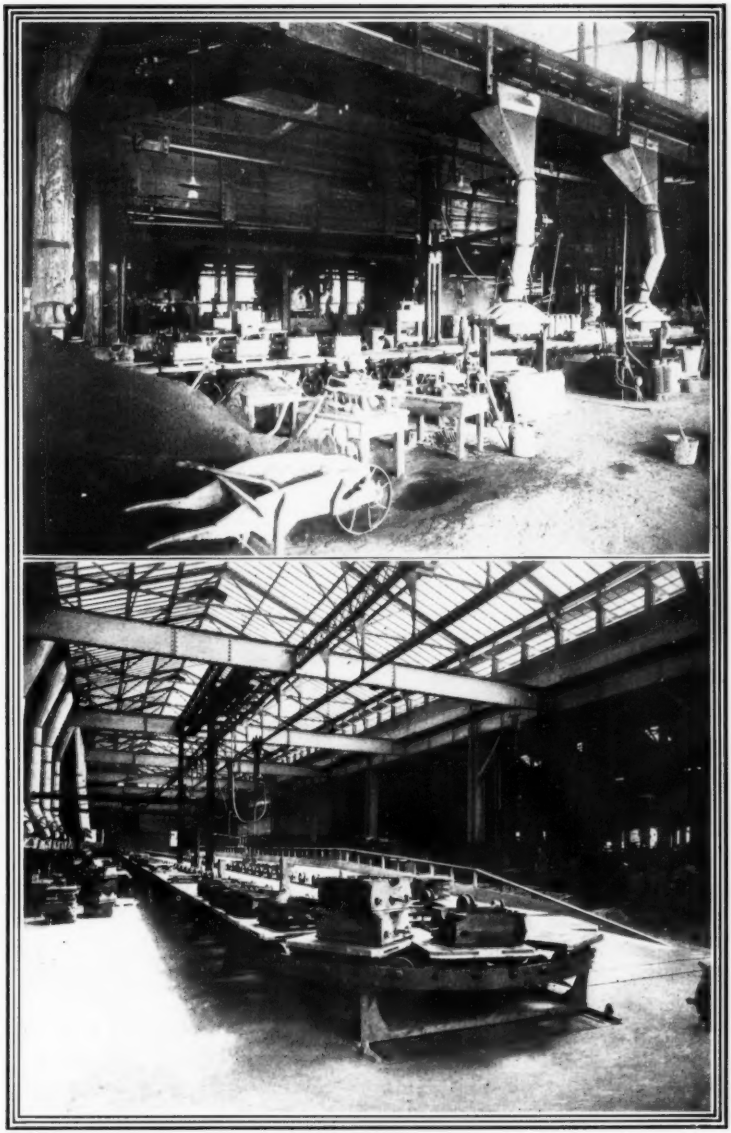
The reverberatory furnace is to a certain extent used in iron foundries for melting irons of special qualities, such as are required for

casting chilled rolls. Greater uniformity is possible, as test bars can be taken from the bath of molten metal and any addition found to be necessary made before tapping. Reducing or oxidising flames can be maintained, and hence the use of this form of furnace in malleable-iron foundries. Malleable castings, before annealing, require the greater part of the carbon to be in the combined state. This can be secured in the air furnace by maintaining an oxidising flame, which converts the free carbon into the combined state. Test bars are taken and the condition of the metal judged from the fractures shown by these bars. When used for melting brass or bronze these furnaces are worked with a reducing flame to prevent loss of zinc or other volatile metal. Even with this precaution considerable zinc is lost. The loss varies with different furnaces, but may be taken as an average of 10 per cent. This loss should be allowed for in making up the alloy.

Reverberatory furnaces may be worked with natural, forced, or induced draught. Natural draught, though slower, gives perhaps the better results. These furnaces vary considerably in design, but the greatest difference lies in the lines of the roof. The work of this roof is to deflect the flame onto the hearth of the furnace, and the amount of this deflection determines the utility of the furnace. The fuel used should be a good flaming coal of the bituminous non-caking variety. Producer gas has been applied to these furnaces in malleable-iron practice, and this fuel should be capable of still further adoption.

Crucible furnaces, as used for melting steel, brass, bronze, or iron for malleable castings, are all more or less of one type. They vary most in sizes and in arrangement of flues, stack, etc. Steel furnaces are generally oval and arranged to take two crucibles. The "holes" are formed of ganister, which is rammed around a wooden pattern the shape of the fire. They are usually relined once a month, all the furnaces in the row being done on the same day, which day is technically termed "building day." The crucibles used seldom contain more than 70 pounds, generally from 50 to 60. They are made of various mixtures of fire clay, and their life is represented by one day's work of three heats.

Crucibles for melting brass or bronze are made from mixtures of fire clay and plumbago and will stand from fifteen to forty heats. The life of the crucibles depends upon the class of alloy melted, the temperature to which the crucible is heated, and the care used in handling. They vary in capacity from 15 to 600 pounds of metal. The heavier sizes necessitate the use of mechanical appliances to "draw" the crucible from the fire. One crucible is used with brass furnaces and the



WESTINGHOUSE AIR-BRAKE WORKS, WILMERDING, PA., U. S. A.

Two views in the foundry, showing the travelling table. The mechanical equipment is probably the most highly-specialised in the world.

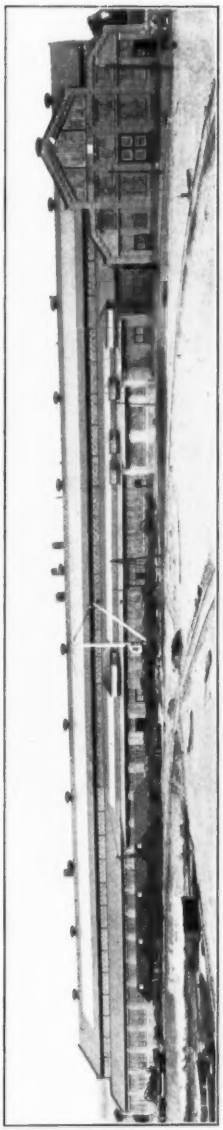
fires are circular. They are built of good fire-brick, which as it wears is patched with ganister or fire clay. Many brass-melting furnaces consist of a cast-iron shell lined up with ganister. Stock shells are carried, all lined and ready for fixing in position, and when a furnace needs repairs the old shell is hoisted out and a stock one placed in.

Continental brass-melting furnaces of the Rousseau and Piat-Baumann type are much in advance of British ones, especially as regards the fuel consumption and life of the crucible.

Crucible furnaces, heated with gas in place of solid fuel, have to a certain extent been adopted. The advantages of such a fuel are that

INTERIOR OF THE GENERAL ELECTRIC FOUNDRY.
Showing travellers and jib cranes.

the temperature is under much better control, there is greater cleanliness, and an oxidising, neutral, or reducing atmosphere can be maintained at will. Gas furnaces are not so severe on the crucibles as are furnaces fed with solid fuel, and therefore the life of a crucible under such conditions is much longer. For crucible fires the Siemens regenerative system is generally adopted, and is in many respects similar to the plant in use with open-hearth furnaces. A producer of the Siemens or Wilson type will permit of inferior fuel or slack being used. A reducing or neutral atmosphere can be readily maintained, thereby preventing a loss of metal by oxidation. This is an undoubted advan-



THE GENERAL ELECTRIC COMPANY'S NEW FOUNDRY, SCHENECTADY, N. Y.

The plant is representative of the best American foundry practice. The ample lighting is especially noticeable, wire-glass in the roof being added to the double clerstory. It is electrically-operated throughout.

tage when it is necessary to preserve the composition of the alloys intact, as is the case with brasses and bronzes.

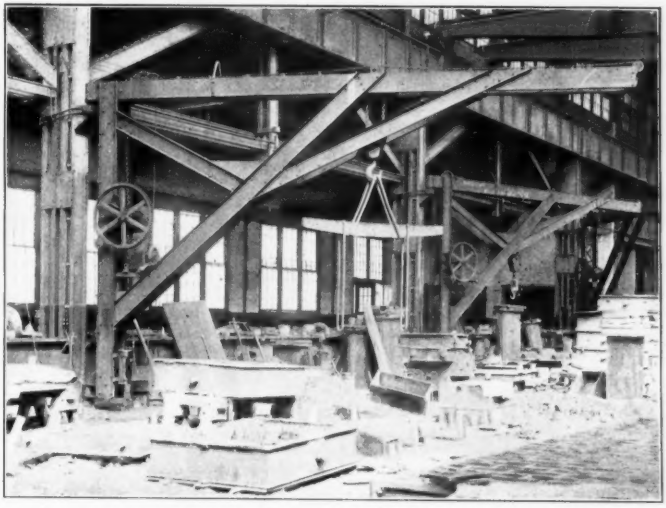
In designing a new foundry an expert founder ought to be consulted, and not, as is generally the case, brought in at the eleventh hour, when all the plant is laid down and the foundry ready for starting work. The heating, ventilating, and lighting arrangements should be up to the same standard as is usual in other departments of an engineering works. It is hardly necessary to urge the importance of a good and free light supply, and indeed the difficulty is to find an excuse for the gloom and dinginess of many foundries. That the roofs should be weather proof goes without saying, but a survey of many foundry roofs in wet weather is not very convincing as to their power of resisting the percolating action of water. With regard to ventilation, there is usually plenty of it in the winter months and a scarcity in the summer, which lends colour to the definition of a foundry being a hot, smoky hole in summer and a cheerless, dismal one in the winter. The arrangement of a foundry will naturally be controlled by the class of castings required from it. Separate buildings are the best for the different metals, though there are cases in which steel and iron or iron and brass are successfully worked under the one roof. A further controlling factor will be the proportion of green and dry-sand to loam castings. Distinct divisions should be devoted to each class of work, and the various tools and materials required by green or dry-sand and loam moulders kept in their respective divisions. An

extension of this system is to divide out the floor into convenient spaces, say the ground covered by the sweep of each jib crane, keeping one class of work and all the tools required for it in the space reserved. By this system no man need leave his own locality and there is no excuse for a man wandering up and down the shop looking for tools or boxes. In not a few foundries as much as one-sixth of the working time is spent in waiting for lifts, looking for materials, boxes, etc.,

USING PNEUMATIC LIFT IN POURING. DEERING HARVESTER COMPANY'S FOUNDRY.

which when found often require putting in order or repairing. The facilities for the entrance or dispatch of materials should be of the best, and not of the kind so familiar—that is, everything coming in and out on the one narrow-gauge track. Such a system in a busy foundry gives rise to many delays. The method of stacking boxes in the yard should be such that any box can be reached with little delay. Oftener than not the stack of boxes resembles a scrap pile more than

anything, and it is no wonder that with such a lack of system the time taken to get a box runs up to half a day. The question of the most suitable lifting appliances for foundry work is one rather open to discussion, but probably the best arrangement is an overhead traveller electrically driven, and hydraulic jib cranes on the wall posts or columns below. The traveller should be of sufficient power to take the heaviest loads, whilst the jib cranes could be of a lighter type, and be used for lifting off boxes, drawing patterns, and putting in cores. A

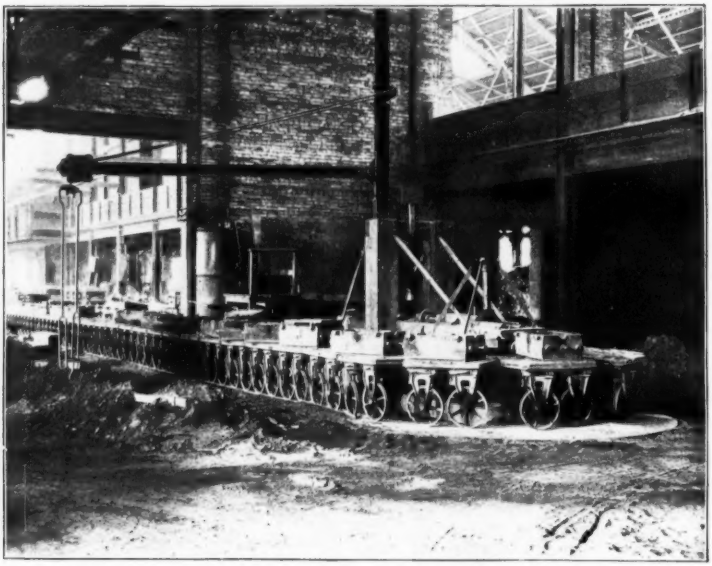


MOVABLE JIB CRANES, GENERAL ELECTRIC COMPANY'S FOUNDRY, SCHENECTADY, N. Y.

Almost every post has pintles fitted to receive these cranes. The traveller can be hooked into a loop at the top of any jib, which can then be carried where wanted, dropped over another set of pins, the electric switches snapped into place, and the jib crane is again ready for work.

travelling crane alone is almost useless, for in the majority of cases fully half the men stand waiting for lifts, most of which are of light loads. One traveller supplemented with jib cranes is preferable to two travellers on the one set of rails. Where much machine or light moulding is done an overhead trolley track is convenient for carrying the metal and casting.

The aid of chemical and mechanical analysis has been referred to earlier, and in the ideal foundry of the future this aid will be fully recognised. To operate a foundry of to-day an exact knowledge of work-



FLASK CONVEYOR IN THE WESTINGHOUSE AIR-BRAKE COMPANY'S FOUNDRY.

The plant is at Wilmerding, Pa., and is used in connection with moulding machine and cupola. Flasks from the machine are placed in the carrier, 225 ft. long, conveyed to the cupola for pouring, and, cooling in transit, are shaken out at farther end of foundry. Link-Belt Engineering Co.

ing conditions must be attained, and the man working such a foundry must have a fair knowledge of the crystallisation and contraction of metals. In addition to his practical knowledge he must be acquainted with metallurgy as far as it affects the metals he uses. Dividing the responsibility between chemist and foreman has not proved a success, and it now remains for the foreman to acquire the scientific knowledge necessary to his branch of foundry work and in which he has unlimited opportunities of applying it. Such, then, should be the qualifications of the head of a foundry of to-day—a man with practical and theoretical training combined; one who can manage men wisely and instill into them the desire of producing efficient work. Such a man would be up-to-date in every respect, and he should be given full control and allowed free scope for his inventive powers. Run on these lines, and with a head master of his business, the foundry as a profit maker will vie with any other department of an engineering establishment.

THE PRACTICAL MANAGEMENT OF MINING OPERATIONS.

By John E. Hardman.

THE mine manager may be called upon to commence his duties with the deposit of mineral practically untouched, or in the condition known in the western States as a "prospect," but usually he assumes his duties after a property has passed its prospect stage, and has been developed sufficiently to afford the data which are necessary to prove beyond reasonable doubts that the deposit of mineral has both sufficient size and sufficient richness to be worked at a profit. If this preliminary work has not been done, the first duty of the manager is to satisfy himself that these necessary factors exist. In the early development of a mine there is but one hard and fast rule and that is, to "follow the ore," no matter how irregular its dip, strike, or general characteristics may be.

It is assumed that there is a record of all previous excavations and tests, of the eccentricities and irregularities in the ore deposit, of whether pay values are confined to "chutes" or are disseminated throughout the matrix, of the amount of water coming into the mine, of the nature and character of the walls of the deposit, of their tendency to "weather," "swell" or otherwise, of the permanence of openings made in the "country," and that, either from previous operations or from the manager's preliminary work, all the facts requiring consideration before beginning permanent works are ascertained or recorded.

A plan and several sections of the property should be prepared with the contour of the surface laid down in lines not over 50 feet apart vertically. These drawings should show the extent or longitudinal dimensions of the deposit, its various widths, as ascertained

Mr. Hardman very properly remarks that the space available in a magazine article does not permit of going into explicit details, but is sufficient only to present the outlines of the practice which should lead to success—that his summary is simply the skeleton, "from which it is frankly admitted many of the smaller bones are missing." The study of anatomy, however, is based upon a thorough knowledge of the skeleton. It is necessary to take away the enveloping fabric and make clear the framework. His paper is thoroughly practical and scientific in revealing the solid structure upon which the body of successful mine management is built up.—THE EDITORS.

both on the surface and underground, the variations in dip of the lode, the trend of the ore chutes, the faults which dislocate the ore body, and such other data as may be known from previous workings. The manager can then determine approximately the daily quantity of ore to be mined, which will help to determine the size of the openings required, the character of the hoisting machinery, and the number of men that can be employed to advantage. With this mapping should be associated a careful assay sheet, so that the pay chutes (if the pay ore is confined to chutes) may be roughly located and their angle of dip known, also their average width and length in the vein. All these data should be carefully noted and used as the basis of determining not only the probable output of the mine when working as a going concern, but also as influencing the location and character of the main openings to be made upon the property.

These tests, or the data they afford, may be regarded as absolutely indispensable before a purchase of the property is made, so that its valuation may be approximated as closely as possible; for one of the principles governing the acquisition of a mining property may be clearly stated as follows, viz.: Does there exist on the property a deposit of mineral of sufficient size and richness to repay all costs incurred in (1) purchasing the property, (2) erecting a plant of sufficient size and capacity to properly work the deposit, (3) to repay all capital expended in development (*i. e.*, in sinking, driving, erecting surface works, etc.), (4) to repay the capital required to cover all transportation charges, either to a public market or public reduction works, or to the company's own reduction works, and (5) last, but by no means least, to yield, after repayment of all these items, a good return or interest on the capital thus employed? Not only must the original investment be repaid, but while it is repaying it must earn a satisfactory interest; it may be pertinent to say that some of the ablest engineers on the American continent consider that the yearly interest on capital invested in metalliferous deposits should never be *less* than 10 per cent., and that 15 per cent. is nearer a just compensation.

With the results of this preliminary work just mentioned should be united a knowledge of the geological structure of the district immediately surrounding the deposit, or "the rule of the camp," as it is called, as shown and proved by the workings of adjacent mines.

The preceding investigations having shown that there exists a profitable deposit of sufficient magnitude to warrant systematic working, the manager will proceed, after consideration of the data ascertained and of the facts available, to consider the main plan of attack, or

of development, for the property. The requisite and proper plant of machinery for such workings, and the determination of whether it is advisable (due regard being paid to the financial condition of the company and the length of time required fully to open the property) for the company to mill, concentrate, or reduce its own ore have also to be considered. The topography and physiography of the property will indicate whether the deposit can best be opened by a vertical shaft or by an inclined one; by an adit upon the vein, or by a cross-cut tunnel. The choice of method having been made, it is necessary to determine the location of the principal outlet from the mine, *i. e.*, the mouth of the shaft or the entrance of the main adit or cross-cut tunnel. The considerations determining this location depend upon the character of the deposit to a very great extent; *e. g.*, whether the deposit is a free-milling ore which can be sent at once to the company's own mill, or a refractory gold ore requiring cyaniding and subsequent treatment of concentrates or vanner heads; whether such sulphuretted concentrates are to be treated by pan method or by chlorination, etc.; also whether the ore is a concentrating one which is to be delivered to the company's own dressing mill or concentration works, or whether it is of sufficient grade to ship at once to a smelter; next, if it is a smelting ore, whether it is sufficiently free from silicious and earthy matter to be smelted or shipped at once, or whether it requires preliminary dressing (by cobbing and picking, or by fine concentration) before shipment is made to the market. These various and varying possibilities require careful consideration, as they influence the selection of the site for such dressing and reduction works, so as to reduce the handling and transportation to a minimum. With these matters must be associated the determination of other factors, such as the amount and cost of water available for dressing works or for milling purposes; whether the source of power is to be water or steam, and in the case of water, whether the same is at hand or whether the power from it is to be transmitted, and if so, whether by electricity, compressed air, or otherwise; whether the fuel is to be coal or wood, or petroleum. From consideration of the preceding items the location of the main mine opening and of the surface plant can be determined upon.

The preliminary exploration referred to has given the location and pitch of the pay chutes, the dip of the vein, its lateral extent, and the probable amount of ore which can be won as a daily average. With these data at hand the manager can decide whether to make his permanent working through an inclined shaft, or whether (for reasons of future costs) it is advisable to sink a vertical shaft, located with

proper reference to the dip of the vein and of the pay chutes. It is noted that the practice (formerly prevalent in America) of sinking inclined shafts has already been abandoned in many of the large mining centres in favor of vertical shafts. Notably is this the case in the Lake Superior copper country, in the district around Butte, Montana, and also in the older counties of California. Perhaps the most striking instances are in California, in the counties of Amador and Calaveras. In these sections, several properties which, forty or fifty years ago, were worked by means of inclined shafts are now reopening (or have reopened) with vertical shafts, *e. g.*, the Kennedy, Oneida, South Eureka, and Wildman-Mahoney mines in Amador county, and the Gwin and Lightner mines in Calaveras county. In these instances vertical shafts have been chosen for permanent attack upon veins which were previously opened and worked by inclined shafts; after abandonment (in many cases for years and years) these same properties have been reopened and a second era of profitable existence begun through the sinking of vertical shafts from which cross-cuts have been made to the vein, and with such pecuniary results as have been most pleasing to the shareholders concerned.

The notable success, as managers, of American mining men over mining men of other countries is in quickly and successfully solving the problem: Given a certain sum of money locked up in a certain piece of ground, how can that money be extracted in the shortest possible time at the cheapest cost? A mine is nothing more nor less than a certain amount of money locked up in earthy material; the more quickly that money can be taken out the less interest will have to be paid on the capital invested to take it out, and the sooner the profits realized can themselves be turned into interest-bearing sums. It follows logically that the more quickly a mine is developed the sooner extraction can be begun.

Underground workings, such as shafts, levels, stopes, etc., all have as their ultimate object the making of this extraction as rapid and as cheap as possible. There are, of course, other factors which it is necessary to consider, such as the safety and health of the workmen employed, and (in some cases) the preservation of the surface of the property in undisturbed condition. The carrying forward of these various branches of underground work in the proper way is one of the important duties of the manager, who may delegate the immediate supervision to his foreman, but who, nevertheless, is himself responsible both to his employer and to the law.

In the sinking of shafts, as in almost all other underground devel-

opment, it is advisable that such work should be done by contract rather than by day's pay. The reasons for this are manifest. The main factors involved are those of labor and time; and it is an axiom that a man working for himself will do a greater amount of work in a given time than one working for an employer; it is equally axiomatic that a workman who pays for his supplies will use greater economy, and make a given quantity go a longer distance than when the company furnishes them. Similarly, a greater care of the machinery used for removing rock and water is observed on contract work than on day's-pay work, for the reason that damages are charged directly to the contractors, if any occur.

Since a manager's tools are chiefly his professional ability, his knowledge of general business and of men, one of his first duties is to obtain a good underground foreman. The selection of a foreman is a paramount consideration; the foreman should be chosen for his experience and his record as an economical worker, as well as for his capacity in handling labor. The latter qualification is one which is natural to some individuals and impossible to others, and a foreman who has this faculty can easily acquire the necessary experience and the record in a comparatively short time. The benefit of choosing such a man from the ranks of the workmen is considerable; he has a knowledge of men's likes and dislikes from themselves, and knows also their actual worth. Such a man has the prestige of being "one of themselves," as it were, and they recognize his superiority from the fact that he has been chosen to do work which is above them; they also know that they can not deceive him as to their work.

Economical sinking depends upon a factor which is often overlooked, viz., that as much attention should be paid to "mucking," or means of taking broken rock away from the miners, as to the facilities afforded such miners for breaking the rock. It is notable that a very large part of the success which attended the sinking of the vertical shafts in the Lake Superior region, particularly at the Tamarack mine, was due to the very complete arrangements made for the mucking away of dirt and rock as fast as possible from the men. I have said that this feature is often overlooked, and I think it is within the memory of every professional man who has had practical experience in mining that the commonest way in which his foreman "falls down" is from his lack of attention to this "mucking" of dirt. Another point in the sinking of shafts (particularly in the sinking of a vertical shaft) is the relative economy or advantage of sinking (as was done at the Red Jacket shaft on the Calumet) entirely with the tub or bucket, a

cage being installed only when all the sinking was finished. Notable examples of good shaft sinking are found in the Butte copper district, Montana, as well as in the Lake Superior country, one of the most recent being the new shaft on the Mountain Consolidated mine, and also the shaft of the Speculator mine in the same district.

When it is desired to make a production during development of the mine, levels are driven as soon as the shaft has reached a depth of 100 or 150 feet from the surface, and then the sinking is continued. Where shafts are sunk upon the vein (and vertical shafts also) it is good practice to follow the old Cornish method of leaving a "pentice" * at the first level, and to sink below that by means of an auxiliary rope or winding machine. This pentice is afterwards removed as soon as the shaft has reached the depth required for another level. By repeating this process the shaft is sunk continuously, without interfering with the regular hoisting of ore from the mine coming from lateral developments above. In the case (which is rare) of properties that are well-known to be continuous and of large extent, and to contain ore of good marketable grade with a ready sale in the market, it is economy to do all the sinking (or a very large amount of it) before turning off levels. The broken rock then coming from levels, raises, and cross-cuts is handled to the best advantage both as to time and economy.

An equally important matter is the care taken to prevent surface water from reaching the bottom, or in other words, to conserve and stop such surface water at the highest point possible in the mine. In the vast majority of cases the bulk of the water which has to be pumped comes from the surface, that is to say, it comes *above* rather than *below* the depth of 300 or 400 feet. This statement is made with due recognition of the fact that many mines have been dry until large bodies of subterranean water were encountered, but such exceptions emphasize rather than disprove the statement just made. "A manager is known by his dumps," but it is equally true that the capacity of the manager is as often shown by the manner in which he provides for the accumulation and pumping of the water coming into his mine.

Before driving levels to any length, a chamber, plat, or station should be excavated. The location of this chamber or plat in a vertical shaft is not of so much importance, but with an inclined shaft the station must, of course, be made in the hanging-wall of the vein and be carefully timbered or supported, with proper room for switching or

* *Pentice*, derived from the French word *"appentis"*; correlative of the English "penthouse."

dumping cars opposite the winding compartments. A mistake frequently made is in not excavating such a chamber or station of a sufficient height to permit long sticks of timber, long pipes, or other lengthy material to be taken off the cage or skip, as is necessary with wide ore bodies where sills are required to be laid underneath the setts in order to catch and take up properly the subsequent setts in levels below, or (in the system of cross-cribbing largely practiced in Australia) to support the cribs when stoping up from below.

A consideration of paramount importance in the driving of levels upon an ore body is the width of the lode which it is desirable to break. In the case of a wide deposit of ore, or of levels penetrating chambers or enlargements of a vein which otherwise may be comparatively narrow, the amount or tonnage of ore coming from such levels is the chief factor. In most cases a double-track level is entirely unnecessary, provision for rapid tramming and the passing of empties by the fulls being made by "turn-outs." A level 6 feet in width by 7 feet in height, with turn-outs where necessary, is usually sufficient for any metalliferous mine, and in the development of smaller bodies, where the ore body is not as wide as the level, the level should be carried its full width, breaking into foot or hanging-wall, whichever may be the better. Often this is the cheaper, for the reason that the cost of labor and explosives per running foot is *less* than if the miner had to work in a narrow space and confine himself to the natural walls of the vein.

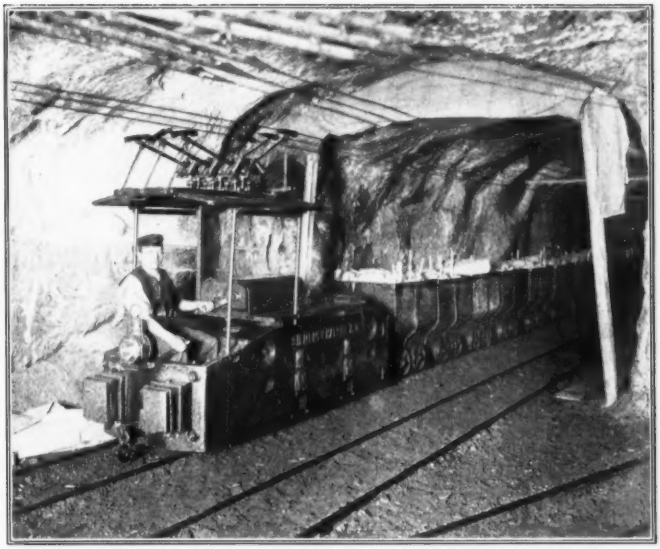
The amount of water coming through a level has an influence as regards ventilation upon the height to which it should be carried. If this amount is large, it is advisable to make a gutter either in the centre or to one side of the level, over which the sills or stringers for the track can be laid; in the case of wet mines such a gutter is a necessity. In long drifts, or where the natural ventilation is bad, a greater height is needed, the air "sollar" being placed in the roof in dry mines. The manager will of course satisfy himself as to the nature of the rock, the character of the walls, the occurrence or non-occurrence of slips, and their dip; whether it is desirable to drive his levels by the "centre cut," "side cut," or some other method. As the object of the levels is twofold—(1), to open up the ore for quick extraction, and (2), to provide for the transportation of such ore (when mined) as well as waste rock and water, *outwards*, and timber, tools, and supplies *inwards*—the grade of such levels becomes a matter of considerable moment. If the bulk of the tramming is done towards the shaft, and very little away from it, the grade may be permitted to be steeper than if the large percentage of the tramming is inwards from the shaft; the

amount of timber which the stopes require supplies most of the inward traffic. As a general statement, the nearer such levels are driven to a "dead level," or say to a grade not exceeding 4 inches to 100 feet, the better; and when levels are long and unstoped, the ventilation will be better the less the grade is.

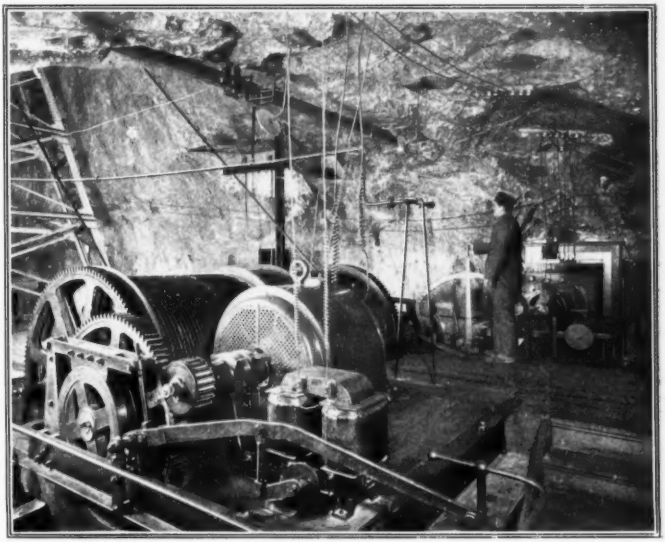
The same remarks that were made in regard to contract work in sinking may be applied to driving levels, and the wise manager will satisfy himself as to right prices in various ways (for example, by driving a new level for, say 30 days, by day's pay and under close inspection from the foreman, with an accurate tabulation of costs). Manifestly a "company account" price should be above the maximum for contract work. Local conditions of labor will determine whether contracts are to be let by the running foot, by the square foot of cross-section, or by the cubic foot of material taken out.

Cross-cutting, or tunnelling, becomes important only when the mine is opened by a vertical shaft and the ore body is found by cross-cuts, or when the main opening to the deposit is by a large cross-cut tunnel, or where there occur veins, parallel to the main vein, which are profitable to work. The essential distinction, so far as the management is concerned, between a tunnel and a level is that such tunnels usually demand a width sufficient for a double track, and a sufficient height to permit of mechanical haulage, either by mules, horses, or electric power. Under such conditions the average dimensions of such tunnels are about 7 feet high by 8 wide. In the long adits in use at the Hall mines in British Columbia (where haulage is by mules) the timbering is 8 feet wide on the sill level, and 6 feet wide on the cap level "in the clear," and the vertical height is 7 feet. In Colorado, at the Stanley mine, it has been found in the "road adit" that a single track, with turnout sidings, is preferable to a double track; all determining conditions are local with each individual property. The same considerations apply to cross-cuts from a vertical shaft to cut a vein, also to cross-cuts driven from one vein to a parallel one, when they are made for working purposes, and not simply for prospecting. The matter of drainage in main cross-cuts is important in many cases.

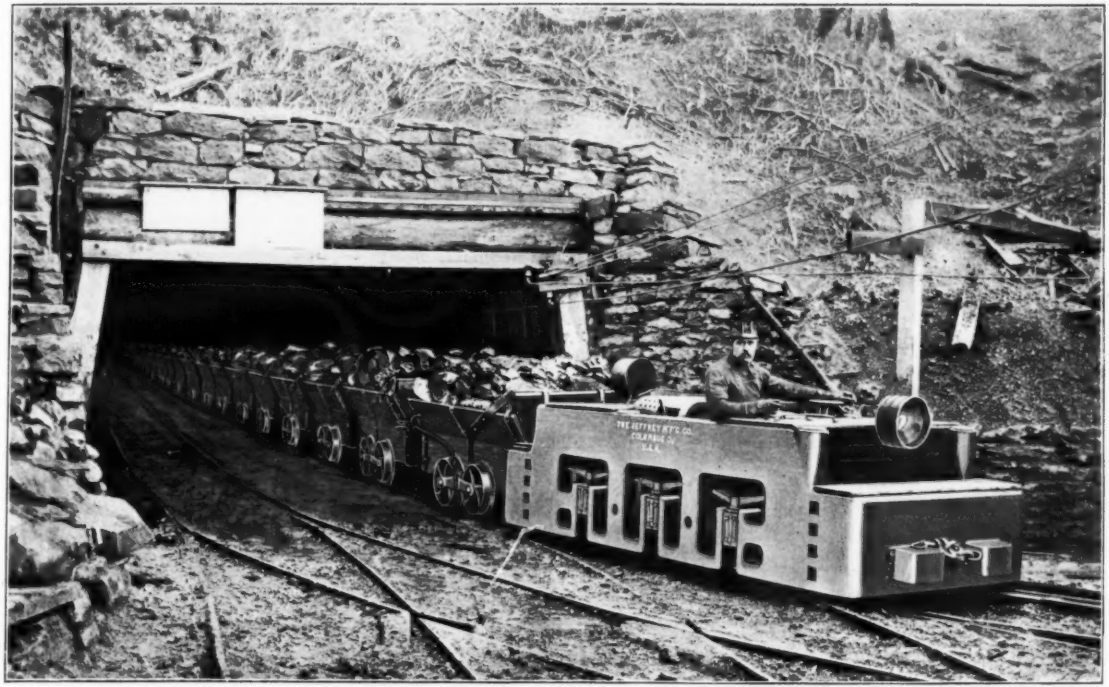
The primary object of raises is to open up faces for stoping the deposit, as well as for prospecting and for ventilation. The raise is really a part and parcel of the stope, and its dimensions must be governed by the width of the ore body, or the amount of ore which it is designed to pass. As they should be permanent, being most valuable factors in ventilation, and also useful as gangways, they should be driven upwards along the foot-wall (or *in* the foot-wall) of the de-



Three-trolley electric locomotive with train of loaded cars coming out of a German mine. Siemens & Halske system.



Electric winding engine used in the mines of the Consolidated Alkali Works, Germany.



ELECTRIC MINE LOCOMOTIVE WITH TRAIN OF LOADED CARS, WHEELING & LAKE ERIE COAL MINING CO., DILLONVALE, OHIO.

The locomotive weighs 30,000 lbs., has a draw-bar pull of 5,500 lbs. on the level or 4,300 lbs. on a 4 per cent. grade, is equipped with three 35 horse-power, 220-volt direct-current motors, and maintains a speed of 6—10 miles an hour; its gross load at a speed of 8 miles on level track is 183 tons, on a 2 per cent. grade 70 tons, and on a 4 per cent. grade 39 tons; these rated capacities are exceeded by about 15 per cent. in actual work. The locomotive hauls cars from a parting about 1½ miles from the mine mouth; smaller (6-ton) electric locomotives bring the trips to a gathering switch, from which this 15-ton locomotive does the main hauling. Jeffrey Mfg. Co.

posit, and should be wide enough to permit of partitioning off a compartment for a ladder-way. The reprehensible practice of miners throwing tools down the raise or winze (usually down ladder-ways) will be known to the manager, who will provide against it by furnishing "nippers" or tool-boys, and by holding the miners responsible for all tools lost or thrown into the ore pass.

The distance between upraises depends on the main points of how quickly it is desired to stope out the mineral, the distance to which muckers can throw waste rock, and also upon the amount of waste which has to be stoped and held on timbers. Where there are large amounts of waste and small amounts of ore, the raises may be farther apart, as also when the whole mass stoped is ore which subsequently has to be sent to the surface. In the later case the stopes themselves constitute an ore bin, the broken ore lying upon the stulls until it is needed on the surface, when its place may be taken in the empty stope by rock-filling subsequently sent down.

The methods governing the extraction of ore from a deposit depend upon the deposit's width, whether the whole width or only a part of it contains valuable ore, the nature and character of the walls, and the inclination of the deposit. For wide ore bodies, where the whole or the greater part of the material broken is valuable and where there is comparatively little waste, the underhand stope has advantages: but where a large proportion of the rock broken is waste (*i. e.*, not ore) or when the vein is narrow, with good walls, overhand stoping is to be preferred. Among the advantages afforded by overhand stopes are: that a unit of explosive breaks more ground, gravity assisting it; there is also less handling of broken material, the waste being allowed to lie where it falls; there is better ventilation, and less timber is required than in an underhand stope. The disadvantages are the costs of the raise and the losses of ore which occur in the waste. The underhand stope requires no raise, incurs no loss of ore broken, and is better for veins with flat dips where the ore will not "run" on the wall; but against it are the disadvantages that all the ore broken has to be raised, that lean bodies occurring in the stope can not be left as pillars, that larger amounts of timber are required, that the ventilation is poorer, and lastly that water accumulates. For a narrow lode, where the filling is chiefly of sufficient grade and value to send to the surface, the underhand stope is preferable, but where a large amount of rock has to be broken to get a comparatively small amount of ore the labor of handling such waste prohibits any but an overhand stope.

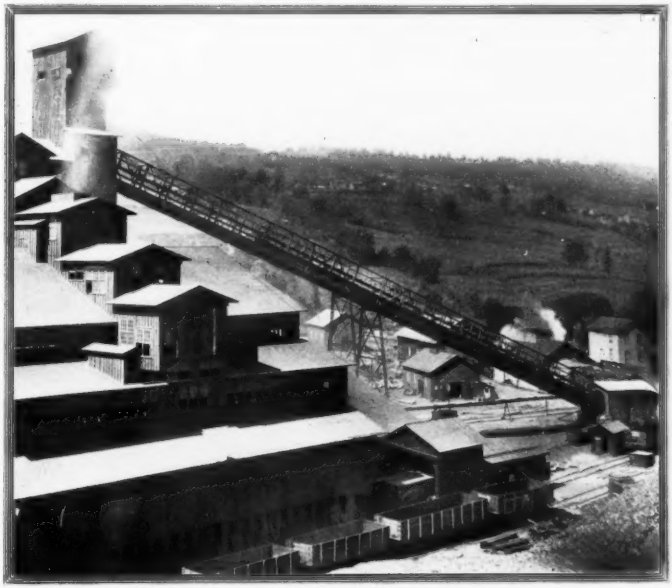
The timbering of the stopes depends upon the width of the ore

body to be removed and the character and quality of the walls enclosing it; the cost of timber as compared with cost of rock filling; and the necessity of keeping gangways open for ventilation, and for possible egress in case of accidents. Where the body is large and the walls are poor, the manager will keep constantly in sight the feasibility of using rock filling, which has been employed to such advantage during the last twenty years all over the world. This rock filling, which is an absolute necessity for some deposits, can be gotten either from the development work proceeding in the mine, *i. e.*, from levels driven in the country rock or from cross-cuts, or it can be sent down from the surface, being quarried from some spot conveniently near the mouth of the shaft. There is no one subject perhaps on which the manager will show his ability, or inability, to fill his post so quickly as in this matter of supervising stopes. He will find his costs varying greatly, according as this matter is properly or improperly dealt with, and he will use up much of the gray matter of his brain in solving the problem.

To get the best results from subordinates and workmen, the manager needs to use a mixture of both intimacy and reserve, which to be successful, depends either upon his "personal equation" or his worldly experience, and perhaps on both. With the subordinates of his staff he must keep constantly in touch; a daily round, with personal conversation, gives the required intimacy. In his conversation, and by questions, he can impress upon each one the necessity for exact information upon the smallest details, which, skillfully done, produces the second desirable effect of reserve, provided he is, and shows he is, a master of the branch he is dealing with. He can also thus impress upon the subordinate the necessity for rigid economy. By his own methods he can give the object lesson desired of rigid economy, full knowledge of detail and loyalty to the company, and, in mining as in other businesses, example is better than precept. If he be careless, he will find the contagion spreading as quickly as a zymotic disease, and proving as virulent.

Each subordinate should be chosen for his knowledge of his particular department, and led to expect from each man under him a fair return for his wages. He must know what every expenditure (either for labor or supplies) *ought* to produce, and if it is not produced, then he must give the very best reasons *why* it is not. By inculcating the precept that, around a mine at least, everything that costs money must produce money; by having no "favorites" of his own and insisting on others having none; by ruthlessly requiring the dismissal of drones, and announcing that all "soft jobs" are reserved especially for him-

self, he will quickly get his staff into the habit of expecting the best results from the money expended; and, as such methods are catching, it will not be long before his staff will require from the workmen under them the same rigid and economical, but square, methods of doing work.



MECHANICAL TRANSPORT FOR ECONOMICAL HANDLING OF THE OUTPUT OF THE COAL MINE.

Installation at the Boston Breaker of the Delaware & Hudson Co., Plymouth, Pa., U. S. A. A 272-foot steel truss supports a monobar conveyor, carrying coal at the rate of 4 tons per minute from cars to top of breaker. Link Belt Engineering Co.

Of the various methods of inducing labor to extra effort, such as the "premium" system, the "bonus," or the profit-sharing idea, there is not room in this article to treat. It is a matter of record that in some mines these schemes have worked successfully; it is equally on record that in others they have not.

The manager will be aware of the many advantages of working "mixed crews," of mingling nationalities as a sort of insurance against labor combinations and strikes, and he will find that a knowledge of men is as important a qualification for a good manager as a knowledge of technicalities; for while one can "hire" specialists in any branch of science he can not hire specialists in the knowledge of human nature.

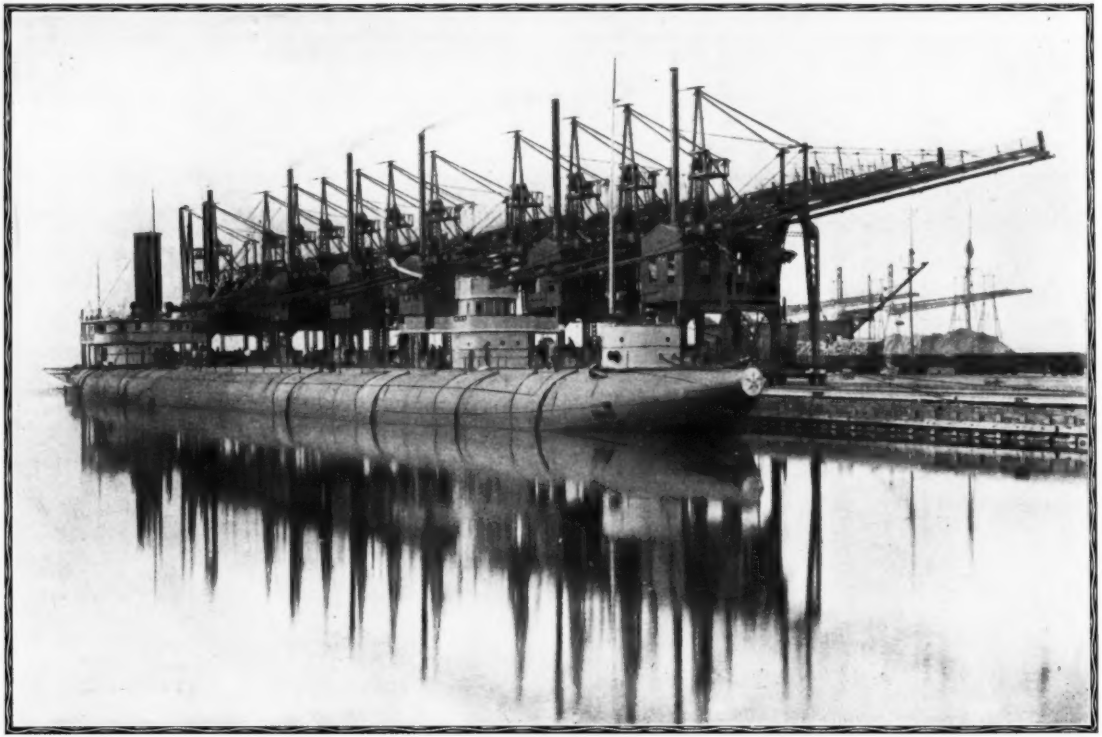
In his supervision of surface operations the manager is governed by the same ideas which influence his administration of underground work, but he should never lose sight of the fact that all labor, to him, is divided into two classes: one, and the smaller usually, which *produces* material from which money is obtained, the other (though useful and absolutely necessary to handle this material) is one which adds no increment to the value contained, but *consumes* a portion of that value in the payment of its wages. Into the latter class come all surface men, and hence the necessity for closest supervision and scrutiny of all surface work. The various ways in which economies may be effected in the boiler-house, in the consumption of fuel, the hand-

ECONOMY IN HANDLING THE PRODUCT OF THE MINE.

Retarding cable conveyor for handling coal, Dayton Coal and Iron Company's mines, Dayton, Tenn.; operated by 15-horse-power electric motor, and fed by three men; 500 feet between centers, travel 100 feet per minute; delivers 125-150 tons run-of-mine coal per hour, without breaking, to a picking table. The tram, which it replaced, had but 1-3 of the capacity, did not give continuous feed to the picking table, and involved much larger wear and tear and running expense.

AN ADVANCED EXAMPLE OF ECONOMY IN AMERICAN COAL-HANDLING PRACTICE. MECHANICAL HANDLING FROM MINE-LOADED CARS TO WHALEBACK LAKE CARRIER.

The plant is that of Coxe Bros., Milwaukee, who ship direct from their own mines to their own colliers. The four bridges shown have each three drum engines, operating 60-cubic-foot grab buckets. A 5-ton weighing scale on each bridge is operated from the scale house shown on top of bridge, above operator's house. Brown Hoisting Machinery Co.



A FACTOR IN THE MARVELLOUS ECONOMY OF MINING THE MINNESOTA IRON ORES. UNLOADING ORE FROM LAKE CARRIERS AT A TERMINAL, PENNSYLVANIA COMPANY'S DOCKS, ERIE, PA., U. S. A.

The bridge tramways have cantilever extensions 80 feet long, extending over four tracks. They usually unload from steamers direct to cars, but have room to store one or two large cargoes on the wharf if no cars are at hand. Loading may be from either wharf or ship into cars. The plant is steam-operated, one engine house serving a pair of machines. The capacity is 1 ton per trip. Brown Hoisting Machinery Co.

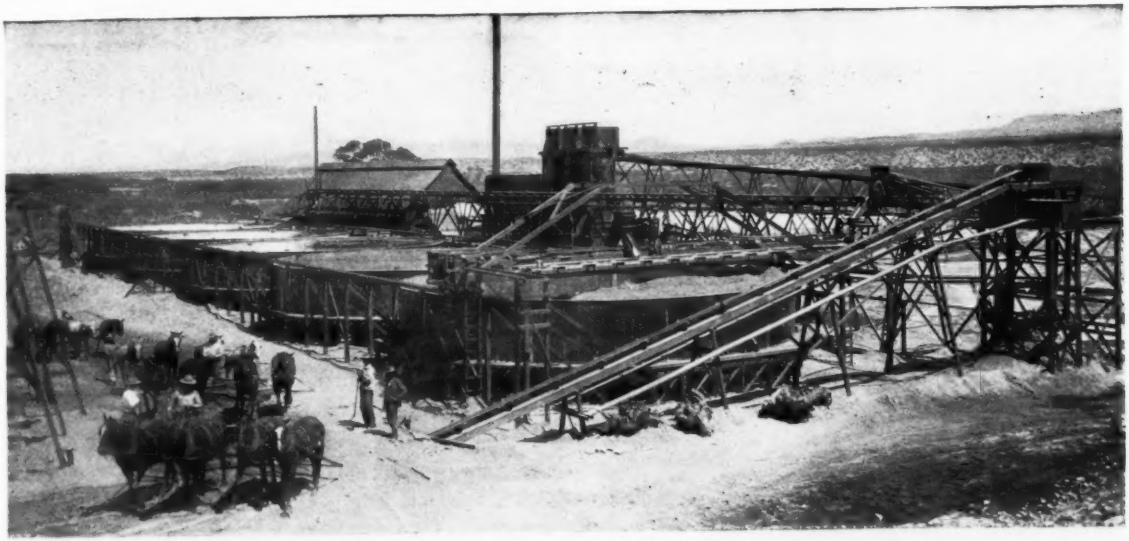
ling of the same and disposal of ashes, the care of grates, etc.; and in the engine-room, where oils and supplies of various kinds may be wasted, or filtered and washed for re-use, are matters demanding the attention of the men employed and the close scrutiny of the manager.

One of the important points in surface work is the prevention of the too-common wasting of ore in the dumps. An old and ever-true proverb is "A manager is known by his dumps," and examples will occur to the reader of the mine dumps he has seen which contained ore, and of the many he knows of that have been sorted and re-sorted at a profit. Daily inspection of the record kept from the "tally" boards, both below and on the surface, and a visit to the end of the dump each day, will set the manager thinking, and will produce an increased tonnage if he is worthy to "hold down his job." A still greater source of waste, perhaps, is found where it is concealed from public observation, viz., in the stopes of a mine. There are many cases where such filled stopes have been profitable ore bodies; where subsequent management has pulled the scaffolds, picked and hoisted the ore, with profit as a result. In precious-metal mines this is perhaps one of the most frequent exhibits of incompetent management. Difficult as it is to sort ore on the surface in broad day-light, it is far more difficult to sort it by the light of candles in dark stopes, yet from the standpoint of small costs and high results, it is often one of the points best worthy of the manager's attention.

A manager has also to satisfy the labor he employs as to comfort and health, if the mine is (as is usually the case), in the wilderness, or apart from villages of considerable size. It does not pay a company nor a manager to have his men discontented or sick, nor to have his force constantly changing because of dissatisfaction. He must therefore give due heed to the "bunk house," and "boarding house." In many places accommodations for the two classes of men, married and unmarried, are needed. Where the latter are employed provisions have to be made for their wives and children, and separate cottages or small dwellings become a necessity. For single men the bunk-houses should be separated into several large rooms, so that "chums" may get together, and that the personal convenience of the different groups of men may be considered. Order and cleanliness must be enforced, and provision made that each sleeper in a room has at least 300 cubic feet of space. For small forces the manager, or one of his staff, with the help of a small medicine chest, can act in cases of illness; for a large force of men, however, it is better to have a resident physician, and charge each man employed a certain amount per month as "doctor's

HIGH ECONOMY IN PLACER MINING THROUGH THE ADAPTATION OF MECHANICAL TRANSPORT.

The upper picture shows the radial travelling cableway—the latest development of this form of apparatus—at the German Bar Mines, Adler Gulch, Montana. The traveling tower, shown in the right foreground, has a speed of 300 ft. per minute. The entire operation of the tower, of digging, hoisting, conveying, and delivering, is performed by one operator and one fireman. The entire area which can be swept is under control of one man. The capacity is 1,000 tons a day. The lower cut shows the hopper, grizzly, and gold-saving sluice.
Lidgerwood Mfg. Co.



SUCCESSFUL REWORKING OF TAILINGS PILE BY THE USE OF IMPROVED PROCESSES AND ECONOMICAL MECHANICAL TRANSPORT.

The illustration is taken from the Mammoth plant, Mammoth, Arizona. Two belt conveyors, a "trunk line," and a "distributing line" are used. The trunk line is carried on a high trestle running parallel with the line of cyanide tanks. The distributing line, running at right angles to it, is supported on a flying bridge spanning the tanks and moving over them as would a travelling crane. The trunk line is provided with a movable tripper which follows the movements of the distributing conveyor and delivers the ore to it. The tripper operating on this distributing line is of the self-driven, self-reversing type and travels back and forth, unloading the belt evenly and continuously. By this system, the ore is carried to any tank and evenly distributed therein, with only one man to superintend the operation of the machinery. The even distribution of the material permits of a more thorough treatment of it than is the case when it is dumped from cars in the center of the tank. At the Mammoth plant, the ore is brought from an old tailings pile by horses and dumped into a hopper flush with the ground which feeds to an inclined conveyor, elevating the ore to the trunk-line conveyor. The installation was made by the Robins Conveying Belt Company.

fees." In the case of smelting works, or of lead mines carrying much carbonate of lead (cerrussite), a small hospital may become necessary. Where the company provides sleeping and eating accommodations for the men it is found best to put this department into the hands of a responsible man, separate from the mine, but subject of course to the manager, who makes such conditions or rules as are for the best interests of the men. This should never be "let out" to a contractor unless under provisions and conditions so stringent as to enable the manager to demand at once rectification of wrongs, and equally demand preservation of order and morality.

Another important point in the management of wet and dirty mines is the providing of a "changing house." Men come off work wet, perhaps with working in wet places, perhaps with perspiration from working in hot places in the mine, and provision should be made for this by establishing a house or room heated by exhaust steam, hot water, or by fires. Such a room or building is best made with a cement floor, as a wooden floor is sure to shrink under the heat, and when full of cracks it can not be thoroughly cleaned. The walls should be frequently whitewashed to sweeten the atmosphere. In wet mines, particularly in shaft sinking, the company has to provide the miners with clothing and boots.

In some countries the manager must be his own magistrate, but in all countries he should thoroughly familiarize himself with the provisions of the mining law of that country and of any special legislation affecting the mineral industry. He should also be versed in the laws governing the hiring of labor and the making of contracts, and of the procedure required to obtain the control of such water-courses or forests as may be necessary for the successful operation of his plant.

In order to produce the best results from capital expended, the manager must be autocratic. Not the least of his duties is to impress on his board the importance of the "one man" power and responsibility. There must be no chance for interference in his organization, no opportunity to appeal from him to his board, by either men or manufacturers, otherwise the regular, and not intermittent, character of the work can not proceed smoothly. With this power must go equivalent responsibility, and then will the company be safeguarded against interruptions by the breaking down of cheap machinery, or by the interference or incompetency of cheap men. No director nor combination of directors, can (or should attempt to) control the manager on these important points. Unity of decision, of authority, and of responsibility are essential for successful mine management.

PRINCIPLES AND METHODS OF PROFITABLY WORKING THE MINE.

OFFICE ORGANISATION, COST-KEEPING, AND RECORDS OF WORK DONE.

By A. G. Charleton.

HALF the art of mine management consists in organisation of one sort or another, so as to secure careful book-keeping, time-keeping, and store-keeping; in the proper checking of measurements, values, and weights, so as to insure their accuracy; and in substituting surveys and working-drawings for guess work and "happy-go-lucky" methods; the necessity for this increases as the undertaking grows in size. It is, however, a fatal mistake to organise the business of a small undertaking at the start on the same lines as those of a large concern, and judgment has to be exercised in avoiding carrying organisation too far, by burdening it with "dead-weight charges" which it cannot stand; just in the same way that a mine may easily be ruined by the premature erection of plant before it is sufficiently developed to justify such an outlay.

I have myself run a fairly large mine, with no assistance beyond that of the mine shaft-bosses and mill-men, with a good machinist to look after the plant; whilst in other cases, a large staff and elaborate organisation, such as I have before described, may not only pay but prove an absolute necessity to secure profit. This is, I think, generally

Probably no branch of engineering enterprise has undergone a more rapid and radical change than has mining. Not only have power applications made the scale of operations in individual mines so vast that only by the most efficient organisation can co-ordination and direction of the whole enterprise to definite and harmonious ends be secured. Not only has a system of management become necessary to carry the individuality of the manager throughout his work. More than this—the position of mining has changed from that of a gaming venture to that of solid industrial enterprise, founded as securely and carried on as econ nically as the business of a specialised machine works.

It is to the commercial mind working in sympathy with the technical ability that much of this reduction to an exact science is due. The methods of registry and record which furnish the engineer with his data are pre-requisite to material success. Systems must be varied to suit special cases, for mining is supremely subject to local conditions; the principles are fixed. To these and to examples of their application Mr. Charleton directs attention in this article.—THE EDITORS.

speaking, more particularly the case where large quantities of a comparatively low-grade ore have to be dealt with, where a few cents per ton one way or the other in the working costs per ton of ore handled make the difference between a large profit and a large loss. Not that I mean to infer that a rich mine is any justification for want of organisation—quite the contrary; but the factor that chiefly decides the question is the magnitude of the operations involved. Hence it is that special attention has to be directed to the subject in mining operations carried on upon a large scale, like those of the Rand, the Alaska-Treadwell, the Homestake, and the copper mines of Butte (Montana) and Lake Superior.

When admissible, such labour-saving devices as the typewriter, shorthand-writer, telephone, and calculating machine will save money in the office, and it is of the utmost importance to systematise the work by the employment of suitable "forms" to be issued to, and filled in by, the different heads of departments; coupled with a method of filing all papers and documents by which any particular form, machinery catalogue, report, or document can be turned up at a moment's notice.

Few mine managers, however, seem to understand thoroughly the function of cost-sheets. They are not, in fact, designed so much to show what has been spent in any particular period (for that is shown by the ordinary mine accounts) as intended to enable the manager on the spot to determine his exact expenditure, from month to month, on *every branch and piece of work* in progress, *separately*, so that he can tell if a stope is paying or is unprofitable, if a level is costing more than it ought to cost to drive, and when a man can be put on or knocked off the pay-roll with advantage; in fact, speaking generally, whether labour and materials are being economised or not. He is then able to put his finger on the right spots, and cut an assured loss or add to profits when it is possible to do so, which is the only certain way to secure real economy. It is to be regretted, moreover, that even in cases where a system of this sort is properly carried out, there are such wide differences in details in the method of subdividing costs that it becomes difficult, if not impossible, to compare the expenses under any particular head in one district, or even in mines in the same district, one with another. It would be a step in the right direction, I think, if the mine managers' associations and chambers of mines in important centres were to discuss the subject and endeavour to arrive at some joint understanding. Excepting in some degree the Rand, I consider the general want of uniformity in the information available at most mines, in matters relating to cost, to be regrettable, because

commercially speaking—so far, at any rate, as regards gold mines—uniformity could do no possible harm to the proprietors and would be of the greatest possible advantage to mining-men generally, by permitting practice at one mine to be compared with that at another; this would enable mine managers to ascertain in what directions costs can best be reduced, where additional saving is possible, and where additional expense is inevitable.

In a paper read before the Institute of Mining and Metallurgy, I have already described in detail the method I have usually adopted myself, which may doubtless be improved upon, expanded, or simplified to suit special circumstances.* By this method, in addition to the ordinary accounts sent to the head-office (accompanied, as is usual, by duplicates of the pay-sheets and vouchers and a fortnightly report in the form of a letter, describing the developments underground and dealing with matters of business generally), the manager should forward home monthly the following cost-sheet forms and returns (which can be found in the paper to which I have referred), keeping, of course, a copy of them at the mine. This is done for the guidance of the company's consulting engineers, as I assume, of course, that a company employs some responsible firm to advise them on professional matters of this kind. Technical experience is necessary to make use of information of this kind and to understand its bearing.

(1)—The Working Expenditure and Revenue Form, showing at a glance the actual expenditure incurred and revenue received during the month, in detail; giving as well a *résumé* of working results, such as: Total number of feet sunk in shafts and winzes, risen and driven, in levels and cross-cuts; total cubic feet or square fathoms stoped; number of tons of ore delivered at surface and crushed; ounces of amalgam and bullion produced; yield in melted bullion per ton; total cost per ton crushed; value of bullion per ounce; assay of ore delivered at the mill and discharged from the battery; tailings assay; assay of concentrates, and quantity of concentrates produced.

(2)—The Mine-Working Statements (divided for convenience into two separate sheets, called A and B), which give the following particulars under tabulated headings of each of the different shafts, levels, winzes, cross-cuts, stopes, etc., in progress, viz:

* NOTE.—This paper can be obtained as originally published, or forms of full size, with an explanatory pamphlet, can be got from the publishers, Howard & Jones, 15 and 16 Cullum street, London.

The distance sunk or driven; total length of drivages; cubic feet or fathoms stoped; width of formation; width of pay ore; average assay value; pan-assay of free-gold; percentage of sulphurets; changes remarked in the lode or country; strike, dip, and throw of faults or cross-courses encountered; tons of ore produced; total one produced to date; number of shifts worked by miners, truckers, and timbermen; the separate gross cost of labour and supplies; the separate cost of labour and supplies per foot of advance (in levels, etc.), and the separate cost of labour and supplies per ton of ore mined (in stopes), in the various working places.

(3)—The Stores-Account Forms, which show:

(*a*)—The quantity and value of stores used each month, charged to the various Mine, Mill, and other accounts, into which Expenditure is split up, in the form first mentioned.

(*b*)—The quantity and value that each item of stores in general use represents, per ton of ore raised, mined, or milled, as the case may be, during the month.

(*c*)—Stores on hand at the beginning of the month.

(*d*)—Stores purchased during the month, and

(*e*)—Total stores on hand at the end of the month.

These three principal series of forms it may sometimes be necessary to supplement by others, such as:

An Assay Form showing:

(*a*)—Widths and values of ore developed, and the calculation of the average widths and values entered on the assay-plan during the month.

(*b*)—General assays of special mine-samples, mill-samples, etc.

A Mill-Working Statement, when, as is sometimes the case, ore is treated for outside parties; that is to say, if "customs work," as it is called, is made a feature of the business.

A Memorandum, giving particulars of bullion, when, as is usually the case, it is melted and refined at the mine.

In using these various forms there is plenty of scope for the exercise of a certain amount of private judgment, so as to adapt details to circumstances without altering the general principles upon which they the framed, upon which I may add a few words.

As regards the Working Expenditure and Revenue: The question to be first settled is to determine the main headings under which it is advisable to classify expenditure, so as to keep expenses of different kinds distinct from one another; under ordinary circumstances it will,

I think, generally be found sufficient to divide them under Mine Account, Mill Account, General and Surface Expenses, and Capital Account. These main headings, to render cost-sheets of any practical value, should, however, in my opinion, be subdivided under various principal sub-headings; as, for instance, I always like to divide Mine Account into:

(*a*)—General Charges: (Including as separate items supervision, hoisting and landing, compressed air, timber and timbering, track-laying, underground tramming, and pit-work.)

(*b*)—Mining.

(*c*)—Development, as shown in the accompanying specimen (Table I., page 691).

(*d*)—Prospecting (diamond-drilling, etc.) may also occasionally demand a separate sub-division.

Sometimes, however, a certain proportion of the above-mentioned General Charges are charged to Mining, and the remainder to Development; whilst in other cases, Development is charged, in whole or in part, to Capital Account; and most frequently of all, General Charges, Mining, and Development are all hopelessly mixed up together under the heading of Mining, without any governing principle at all.

Then again, under the head of Mill Account, it is equally necessary to keep battery-expenses, tailings-treatment (cyanide), and ore-shipment expenses separate, where such charges form part of the working expenses; General and Surface Expenses often include office expenses (itemised), as well as tramming, crushing, and sorting, under separate heads; and in the case of Capital Account, where works are under construction, the cost of the erection of any particular building or piece of machinery should be shown separately and charged to its proper department.

The next question to be settled is the classification of items of expense, under each sub-heading of expenditure.

In this connection I consider that in the case of Development (sinking and driving) and Mining (stoping or "getting ore"), it is sufficient to classify expenses under two divisions:

(A)—Labour.

(B)—Supplies and Stores.

These two elements should appear in *all* the other subdivisions of the cost-sheets, but with various additions.

Thus, under Mine Account, General Charges, and under Mill Account, supervision, fuel, water, tools, and repairs-to-plant, should be shown apart from one another, and under General and Surface Ex-

penses such items as sorting, surface transport of ore, general charges (including rent, taxes, insurance, etc.), and office expenses, ought to be classified separately.

The two great items of expense which enter into every branch of work being, as already said, labour and supplies, particular attention should be directed:

(1)—To accurate time-keeping.

(2)—To showing in the pay-sheets or labour-books how labour has been distributed during the month, *under all the various sub-headings which appear in the cost-sheets, i. e.,* on the Working Expenditure and Revenue form.

(3)—To show in the same way in the Stores-Account forms what stores have been charged under each sub-heading given on the Working Expenditure and Revenue form.

Accurate time-keeping depends largely on the care taken by the time-keeper, or the various foremen in charge of departments, in noting carefully the time spent on different jobs, although men like blacksmiths, carpenters, and others may in some cases be trusted to keep a record of the sub-division of their time upon work under construction. With this object, it is not unfrequently the case that a board (painted black, and specially ruled for the purpose) is hung up in the shops or mill, for particulars that may be required, which are chalked upon it from day to day by the man in charge, and entered by the foreman in his time-book, or on a sheet such as the labour-docket which I advise using.

In any case, the foreman should carefully check the men's time himself for entry in his time-book, and the pay-sheets or labour-books should be so ruled and entered up as to show what jobs each man has been engaged upon; that is to say, the pay-roll, unless due-bills, which are sometimes used (as described by Mr. Hardman), are employed instead, should not only state his occupation, whether miner, trucker, lander, timber-man, carpenter, or blacksmith, but also—supposing, for example, he is a miner—on what face, stope, or job, each man has been engaged, and what time he has put in there. The various working-places and pieces of work may often be distinguished, for the sake of convenience, by distinctive numbers.

Mr. W. B. Middleton, in a paper on "The Segregation of Mine Accounts," read before the Institute of Mining and Metallurgy, February, 1900, describes a modification of the above method, by which each workman is provided with a labour-check, which he fills in himself, and hands in daily at the office; but whatever system is used the

1898.	SECOND QUARTER.—APRIL. Gross.	Total.	Per ton	Total.	MAY. Gross.	Total.	Per ton.	Total.	JUNE. Gross.	Total.	Per ton.	Total.
	£ s. d.	£ s. d.	s. d.	£ s. d.	£ s. d.	£ s. d.	s. d.	£ s. d.	£ s. d.	£ s. d.	s. d.	£ s. d.
MINE ACCOUNT—												
General Charges.												
Superintendence and Labour	491 1 3		13 7.46		473 5 4		12 0 87		363 7 10		10 0.96	
Fuel	99 18 3		2 0.26		128 16 5		3 3.44		82 8 1		2 3.43	
* Supplies and Stores	65 19 2		1 0.96		33 1 1		0 10.12		26 1 10		0 8.68	
Tools	5 3 0		0 1.71									
Repairs					14 17 10		0 4.56					
Mining.		662 1 8		0 18 4.39		650 0 8		0 16 6.99		471 17 9		0 13 1.07
Labour	276 4 0		7 7.04		284 13 4		7 3.14		254 18 4		7 0.85	
* Supplies and Stores	24 3 9		0 8.05		27 7 3		0 8.37		37 5 4		1 0.40	
Development.		300 7 9		0 8 3.99		312 0 7		0 7 11.51		293 3 8		0 8 1.25
Labour	345 18 4		9 7 15		401 17 0		10 3.02		448 8 9		12 5.27	
* Supplies and Stores	37 8 2		1 0.45		37 8 2		0 11.45		55 10 2		1 6.48	
		383 6 6		0 10 7 60		439 5 2		0 11 2.47		503 18 11		0 13 11.75
Total per ton mined		1345 15 11		1 17 3.98		1401 6 5		1 15 8.97		1268 0 4		1 15 2.07
MILL ACCOUNT—												
Labour	142 7 1		4 1.59		152 6 8		3 11.11		148 10 0		4 1.45	
Fuel	74 3 0		2 1.82		64 8 0		1 7.02		61 12 0		1 8.50	
Water	74 0 0		2 1.79		81 10 0		2 1.20		52 15 0		1 5.56	
* Supplies and Stores	26 13 2		0 9.28		21 18 10		0 6.79		17 15 3		0 5 91	
Tools					0 3 9		0 0.06		1 10 0		0 0.50	
Repairs	14 5 0		0 4.96		5 19 6		0 1.85		13 12 6		0 4.54	
		331 8 3		0 9 7.44		326 6 9		0 8 4.93		295 15 7		0 8 2.46
GENERAL AND SURFACE EXPENDITURE ACCOUNT—												
Labour	173 9 0		5 0.42		174 19 10		4 6.12		169 16 5		4 8.53	
* Supplies and Stores	4 13 4		0 1.62		15 17 6		0 4.91		8 18 1		0 2.96	
Transport of Ore					5 12 0		0 1.73		31 17 4		0 10.61	
Tools	2 12 0		0 0.90		0 13 6		0 0 20					
Repairs												
General Charges	7 8 6		0 2.60		7 8 6		0 2.30		7 8 6		0 2.47	
Fuel												
Office Expenses	50 11 6		1 5.61		57 15 2		1 5.87		56 3 7		1 6.70	
Management												
Assaying												
		238 14 4				262 6 6				274 3 11		
Total Mine & Mill Working Costs		1915 18 6		0 6 11.15		1989 19 8		0 6 9.13		1837 19 10		0 7 7.27
Average cost per ton of Ore milled				2 15 7 37				2 11 3.46				2 10 11.80
CAPITAL ACCOUNT—												
Labour	149 17 1				201 2 6				256 10 1			
* Supplies and Stores	70 16 4				319 2 5				105 7 9			
Tools	0 12 6				0 10 3				3 8 9			
Freight									36 17 4			
Fuel												
Supervision												
Contracts for erection of plant												
		221 5 11				520 15 2				402 3 11		
Tons mined		721				784				721		
Tons milled		689				776				721		

* As shown by the "Stores returns." Deducting supplies purchased from the company by contractors.

TABLE I.—FORM FOR GENERAL MONTHLY ANALYSIS OF MINE COSTS.

result should be the same, viz., to enable the number of shifts, or hours spent on each job, to be subsequently entered in a "Detail Labour book"* and "Cost Minute Book"; or on a "Labour-Distribution Sheet," as described by Mr. Middleton, showing what all work has cost so far as concerns labour, and how far each man has contributed a proper and reasonable proportion of time for the wage he receives.

In carrying out the system I use, these particulars should be entered in a special "Labour Ledger," and such of them as relate to driving different levels, stoping, etc., should be shown on the Mine-Working Statement A, besides entering the total cost of labour, under each separate sub-division, on the Working Expenditure form.

To ascertain the exact cost of work, however, accurate store-keeping is no less requisite than accurate time-keeping, and for this purpose it is essential that all requisitions for stores should be made on a Stores Docket, showing to whom stores have been supplied and for what purpose. Full particulars on the latter point should be entered in the Stores-Delivery Books, and details of all such transactions ought to be subsequently entered up in the Stores Ledgers, under various accounts, which should correspond with those running in the Labour Ledgers. Those stores-charges relating to the mine (driving different levels, stoping, etc.), of course, are to be shown on the Mine-Working Statement in the same way as those relating to labour.

Whatever system is employed, a Stores Book, giving particulars of stores received, must be kept, as well as a Mine-Stores Delivery Book, which may be used in conjunction with separate Mill and General-Stores Delivery Book, for convenience's sake, in place of only one Stores-Delivery Book.

In the same way, the Stores-Account forms sent to the home office may either be divided under separate headings, such as Mining General-Charges Account, Mine Account, Development Account, Mill Account, General Surface Account, and Capital Account, to correspond with the subdivision of the Working Expenditure form, or one form may be used, ruled the same way as that form, but with a number of extra columns, showing the total amount and value of each item of stores consumed, and its cost per ton, chargeable to Mine General-

* The fine point to which this requires to be carried in shop-practice, in order that the employer may realise full value for the time for which he pays, has been well shown in many papers on Cost Keeping in this Magazine and in an article in the *Iron and Coal Trades Review* of Nov. 10, 1899, entitled "An Automatic Cost Distributing and Accounting Plan"; a time-recorder, registering on a strip or card-system, being employed in this latter case to check the men's time.

Charges Account, Mine Account, Development Account, Mill Account, etc., for which the extra columns in question are set apart.

Assuming that an equally careful record has been kept of such items of expense as fuel, mine timber, lumber, and water—which do not strictly come under the head of stores, but which should be entered in the Stores Book, Stores-Delivery Books, and Stores Ledgers—and of various general expenses, such as office expenses, freight, insurance, and taxes, etc., which are charged in the mine head-office ledger, a manager is now in a position to ascertain not only what his expenses have been, but the various directions in which they have risen or fallen. He can consequently enquire into the causes that have contributed to a rise or fall in cost, with a view to profit by this knowledge in the future, providing only he possesses the necessary experience and technical knowledge; otherwise, it is more or less labour thrown away, for which the company pays without deriving any substantial material benefit.

The pay-rolls and stores-accounts, although they provide the material, are not of themselves in a suitable form for the purpose aimed at, as what is wanted is to see at a glance each month where expenses have risen or fallen, and immediately to locate the cause of the one, as much as of the other. To effect this, the first step that should be taken is to enter the figures given from month to month in the Working Expenditure form in the manner shown in Table III., headed "General Analysis of Mill Account Costs," a similar analysis being made of each of the other subdivisions of Table I., which affords an example of the monthly entries as they appear in the Working Expenditure form. The next step is to make a detailed analysis of the labour (as shown by the pay-sheet) under each subdivision of Table I., of which an illustration is afforded by Table IV., which shows how mill-account labour is treated. The third step is to dissect supplies. in precisely the same manner, from the particulars given in the Stores-Account forms, and similarly to deal with the quantities of timber, fuel, water, etc., charged to each sub-account.

With these data, there is no difficulty in presenting a summary of working costs, half-yearly or annually, as shown in Table II., which, in the instance shown, is amplified by special analysis of the Mine General Charges, the Mining Account, Development Costs, and Mill Account, designed further to itemise and distribute the totals given; or, with the aid of the labour and stores-ledgers, to keep a cost minute-book on the system described by Mr. Hardman (as exemplified in

TWELVE MONTHS.	GROSS.			PER TON.		TOTAL PER TON.		
	£	s.	d.	s.	d.	s.	d.	
MINE GENERAL CHARGES—								
Superintendence and Labour	4811	1	5	9	1.383			
Fuel	1266	17	10	2	4.803			
Supplies and Stores	505	13	10	0	11.497			
Tools	39	11	1	0	0.899			
Repairs	97	7	7	0	2.214			
	6720	11	9			12	8.796	
MINING—								
Labour	3363	16	9	6	4.479			
Supplies and Stores	344	15	0	0	7.838			
	3708	11	9			7	0.317	per ton mined (10,556).
DEVELOPMENT—								
Labour	4770	19	3	9	0.472			
Supplies and Stores	656	14	7	1	2.933			
	5427	13	10			10	3.405	
MILL—								
Labour	1882	8	3	3	8.510			
Fuel	937	18	4	1	10.179			
Water	1005	11	6	1	11.777			
Supplies and Stores	335	8	9	0	7 931			
Tools	6	10	1	0	0.153			
Repairs	151	0	1	0	3.570			
	4318	17	0			8	6.120	
GENERAL AND SURFACE EXPENSES—								
Labour	2241	13	3	4	5.004			
Supplies and Stores	133	11	11	0	3.157			
Transport of Ore	37	9	4	0	0.885			
Tools	21	4	5	0	0.496			
Repairs	14	12	6	0	0.345			
General Expenses	115	14	10	0	2.736			
Fuel	152	4	10	0	3.599			
Office Expenses	585	9	7	1	1.843			
Management	208	4	11	0	4.924			
Assaying	23	16	8	0	0.563			
	2534	2	3			6	11.552	per ton milled (10,150).

TABLE II.—YEARLY SUMMARY OF MINE WORKING COSTS.

Ton-nage	Months.	Labour. Gross. £ s. d.	Labour. Per Ton. £ s. d.	Fuel. Gross. £ s. d	Fuel. Per Ton. £ s. d.	Water. Gross. £ s. d.	Water. Per Ton. £ s. d.	Supplies Gross. £ s. d.	Supplies Per Ton. £ s. d	Tools. Gross. £ s. d.	Tools. Per Ton. £ s. d.	Repairs. Gross. £ s. d.	Repairs. Per Ton. £ s. d.	Gross Cost. Total £ s.	Gross Cost. Per Ton. £ s. d.
1241	January	257 0 8	4 1 71	105 12 6	1 8 43	94 1 6	1 6.19	19 0 8	6.33			4 19 8	.96	480 15	0 7 8.97
739	February	149 15 1	4 0 62	66 17 10	1 9.72	103 5 0	2 9.53	19 9 4	6.33			3 16 0	1 26	343 3	10 9 3.46
732	March	140 17 6	3 10 19	66 0 0	1 9.64	77 15 0	2 1.49	19 7 1	6.34					303 19	7 8 3.66
689	April	142 7 1	4 1 59	74 3 0	2 1.82	74 0 0	2 1.79	26 13 2	9.28			14 5 0	4 96	331 8	3 9 7.44
776	May	152 6 8	3 11 11	64 8 0	1 7.92	81 10 0	2 1 20	21 18 10	6.79	3 9	.06	5 19 6	1 85	326 6	9 8 4.93
721	June	148 10 10	4 1.45	61 12 0	1 8.50	52 15 0	1 5.56	17 15 3	5.91	1 10 0	.50	13 12 6	4.54	295 15	7 8 2.46
730	July	150 11 8	4 1.52	66 0 0	1 9.70	60 15 0	1 7.07	28 2 6	9.25	1 1 4	.35	7 14 6	2 54	314 5	0 8 7.33
702	August	165 8 4	4 2 12	77 5 0	1 11 42	75 15 0	1 10 96	58 11 6	1 5.75	3 1 6	.93	22 0 0	6 66	402 1	4 10 1 84
922	September	143 14 2	3 1.41	71 0 0	1 6 47	86 0 0	1 10.39	15 8 2	3.97			32 11 2	8 48	348 10	6 7 6 72
965	October	148 15 0	3 1.00	73 0 0	1 6.15	89 15 0	1 1 10 32	48 18 11	1 0.17			8 13 4	2.16	369 2	3 7 7.80
1035	November	146 16 8	2 10.05	122 0 0	2 4 30	109 15 0	2 1.44	31 0 8	7.19	13 6	.16	16 14 2	3.87	427 0	0 8 3 00
868	December	136 4 7	3 4 46	90 0 0	2 2.73	100 5 0	2 5 78	29 5 1	8.69			20 14 3	6.15	376 8	11 9 3 82
10150		1882 8 3	3 8.510	1037 18 4	1 10.179	1005 11 6	1 11.777	335 8 9	7.931	6 10 1	.153	151 0 1	3.570	4318=17= 0	=8 6 12

TABLE III.—MILL ACCOUNT.

GENERAL ANALYSIS OF COSTS.

695

Months.	Mill Men. Wages. £ d. s.	Mill Men. Shifts.	Amalgamators. Wages. £ s. d.	Amalgamators. Shifts.	Battery-Men. Wages. £ s. d	Battery-Men. Shifts	Feeders. Wages. £ s. d.	Feeders. Shifts.	Engine Drivers Wages. £ s. d.	Engine Drivers Shifts.	Various Attendants Wages. £ s. d.	Various Attendants Pumps. £ s. d.	Gross Cost. Total. £ s.	Cost per Ton. s. d.
January	29 0 0	57¾	38 3 4	79	39 10 0	75½	37 15 0	79¼	52 15 1	14	5 16 8	54 12 4	406 15 9	
February	34 0 0	51½	34 6 8	85	42 10 0	72	36 5 0				2 1 8		140 17 6	
March	27 0 0	29¾	19 16 8	59¾	29 17 6	56	28 0 0	54¼	36 3 4	5			142 7 1	
April	26 0 0	27⅝	18 8 4	58⅞	29 8 9	65	32 10 0	54	36 0 0				152 6 8	
May	27 0 0	31¼	20 16 8	58	29 0 0	78	39 0 0	54¾	36 10 0				148 10 10	
June	26 0 0	29⅝	19 15 0	58¼	29 2 6	72	39 0 0	52	34 13 4				150 11 8	
July	26 0 0	30⅝	20 8 4	61	30 10 0	73	39 0 0	52	34 13 4				165 8 4	
August	28 0 0	31¼	20 16 8	63¾	31 17 6	81	40 10 0	56	37 6 8	13¾	6 17 6			
September	26 0 0	24⅜	16 8 4	53⅝	26 16 3	73⅞	36 18 9	49¼	33 3 4	8¾	4 7 6		143 14 2	
October	26 0 0	28¾	18 8 4	57½	28 15 0	76½	38 5 0	51½	34 6 8	6	3 0 0		148 15 0	
November	26 0 0	28½	19 0 0	57	28 10 0	78	39 0 0	51½	34 6 8				146 16 8	
December	27 0 0	25⅞	17 5 0	49⅞	24 18 9	69¾	34 17 6	48¼	32 3 4				136 4 7	
	328 0 0		263 13 4		370 16 3		441 1 3		402 1 9		22 3 4	54 12 4	1882 8 3	3 8.510

TABLE IV.—MILL ACCOUNT.

ANALYSIS OF LABOUR.

Tons Milled.	Approx. gross cost	Total	Cost per ton milled.
	$	$	$
Mining Account—			
Sinking			
Driving			
Stoping			
General			
Explosives			
Stores and Materials			
Milling Account—			
Wages			
Stores and Materials			
Cyaniding Account—			
Wages			
Chemicals			
Stores and Materials			
Fuel Account—			
Cords used			
Cords Stacked			
General Account—			
Engines and Foremen			
Clerking, Assay and Office			
Freightage, etc.			
General and Incidental			
Stores and Materials			
This month			
In previous months			
This year, Total			
Capital Account—			
Development (mining)			
Surface (labour)			
Prospecting (labour)			
Materials and Plant			
Totals			

MINE REPORT.

Mine Workings—	Sunk or Driven during month. Ft.	In.	Total Ft.	In.	Width of Vein. Ft.	In.	Av. Assay Value. $ Per ton	Tons Milled.

Remarks.

MILL REPORT.

Period.	Hours Run.	Tons Milled.	Bar Gold. Weight. Oz. dwts	Bar Gold. Approx value $	Concentrates. Weight Tons cwts grs	Concentrates. Value per ton $	Tailings Assay per ton $	Mill rock Assay value per ton $
This month								
In previous months								
This year								

CYANIDE REPORT.

Period.	Tons Treated.	Assays. Before.	Assays. After.	Extraction.	Smelted Bullion. Weight Oz. dwts.	Smelted Bullion. Value $
This month						
In previous months						
This year			Concentrates.			
This month						
In previous months						
This year						

SUMMARY OF WORKING COSTS.

Department	This Month. $	Cost per ton $	In previous Months. $	Cost per ton $	This year. $	Cost per ton $
Mining account						
Mill account						
Cyanide account						
Fuel account						
General account						
Total						

Store and Kitchen.	Dr. $	Monthly Wages and Cash Receipts.	Cr. $
Cash sales		Wages, Store	
Cash in hand		Wages, Kitchen	
Totals			

Total wages for the month $

Other payments as per vouchers

Outstanding accounts

Remarks

TABLE V.—FORM FOR MONTHLY REPORT AND WORKING COST STATEMENT OF A SMALL MINE, AS EMPLOYED BY MR. CHARLETON.

Tables VI. and VII., pages 698 and 700), eventually posting the various accounts opened in each month into a general costs ledger.

Detailed information of the progress of the workings can be obtained or calculated for the year and analysed from the data supplied by the Working Expenditure form and Mine Working Statement (when these have been properly filled in month by month).

In some cases it is of course necessary to keep separate track of contract work and of work done on day-pay, or of work done by hand, as distinguished from work done with machine-drills. In others, it may be desirable to ascertain the cost per cubic foot or per ton of rock stoped, as compared with the cost of each cubic foot or ton of ore obtained, to show the proportion between ore and waste mined; for which purpose the Mine-Working Statement can be used, if the "average width stoped," be entered, in substitution, in the column headed "width of formation" (page 688).

Where fractions of men's time have to be subdivided, or costs have to be reckoned on any given unit, such as tons milled or feet driven, the money value they represent should be carried out decimally to two or three places of decimals of a penny or cent, to avoid disagreement (amounting, it may be, to several pence or cents) in totalling different items. No stores should be delivered without a proper requisition, which may be supplied to the different foremen or heads of departments, as Mr. Hardman suggests, in the convenient form of a pad, each form being stamped with a consecutive number.

The store-keeper may keep the stores book and stores-delivery books, or make a daily report on slips to the office. In the latter case, the account of stores received and delivered should be kept in the head mine office, which is perhaps to be preferred, all freight and transport charges, together with the cost of handling and distributing stores, being thus easily added at once, *as they must be,* to the invoice cost price of all goods entered in the stores books, so as to show the actual cost-price at the mine of each article charged against the various accounts in the stores ledgers or cost minute books.

Company's stores, kept for supplying the workmen with necessaries, such as food or clothing, are of course entirely separate from these supply accounts.

All general stores should be kept in a closed store-building, which should only be open at stated hours in the morning, mid-day, and evening. To prevent waste and pilfering, stock should be taken periodically, and Mr. Hardman gives a form of general ticket, which can be kept on the bin or rack in the store-room or on file in the store-room

DECEMBER. 189.....

DAY.	Candles.	Dynamite.	Fuses.	Shanks.	Steel.	Drill Parts.	Handles.	Shovels.	Spikes	Nails.	Soap.	Time fuse.		Labour.	Ore.	Waste.
1 S																
2	4	5	10	...	321	.....	.. .	....	....	....	....	.....	.....	$14 02⅜	.....	7
3	4	5	....	104	.....	.....	....	....	....	....	....	.....	.....	12 00	18	8
4	4	5	12	....	.....	.....	....	....	....	....	....	.....	.....	10 07½	.....	5
5	4	5	....	96	.....	.....	....	....	....	....	....	.....	.....	8 30	.....	.....
6	4	5	10	....	.....	.....	....	...	...	....	....	.....	.....	11 70	.....	12
7	4	5	...	73	.....	.....	...	...	....	....	....	.....	.....	9 70	.....	15
8 S																
9	4	5	10	60	.....	.....	....		....	.....	....	50	.....	10 05	.....	.....
10	4	5	....	....	.....	.....	....	....	....	....	....	.....	.....	9 60	.....	5
11	4	5	....	114	.....	.....	....	....	....	....	....	.....	.....	11 54	.....	8
12	4	5	6	52	.....	.....	....	....	....	....	....	.....	.....	7 62½	.....	6
13	4	5	....	50	.....	.....	1	....	....	....	....	.....	.....	7 62½	.....	11
14	4	5	10	61	.....	.....	....	....	....	....	....	.....	.....	8 85	.....	4
15 S																
16	4	5	....	....	.....	.....	1	....	....	....	....	50	.....	8 10	.....	3
17	4	5	5	131	.....	.....	..	1	....	....	....	.....	.....	7 90	.....	8
18	4	5	...		.....	$1.30	....	....	....	....	....	.....	.....	10 27	.....	5
19	4	5	....	111	.....	1.00	....	....	....	....	....	.....	.....	8 20	.....	5
20	4	5	10	....	.....	.....	....	....	....	....	....	.....	.....	8 25	.....	5
21	4	5	....	120	.....	.....	....	....	....	....	....	.....	.....	8 25	.....	9
22 S																
23	4	5	10	49	.....	.....	....	....	....	....	....	.....	.....	11 50	.....	5
24	4	5	....	....	....	.....	....	....	....	....	....	....	.....	9 60	.....	6
25	4	5	....	116	.....	.....	....	....	....	....	....	.....	.....	7 90	.....	8
26	4	5	10	98	.....	.....	....	...	....	....	....	.....	.....	8 25	.....	8
27	4	5	....	....	.....	.....	....	2	....	....	....	.....	.....	8 25	.....	8
28	4	5	10	37	.....	.....	....	....	....	....	....	.....	.....	8 25	.....	9
29 S																
30	4	5	....	....	ret'd	.....	....	....	....	....	....	.....	.....	11 70	.....	.....
31	4	5	....	129	293	.....	...	....	....	....	...	.....	.....	11 70	.....	25
Totals	104	130	103	1411	28	.....	2	4	....	....	....	100	.....	$249 39	.....	186
Prices	.11	.16	.045	.03	.14	.....	.10	.81	....	....	....	.0053	Proportion for Superintendence	$32 47	.....	.....
80.165	11.44	20.80	4.635	42.33	3.92	2.60	.20	3.24				.53	Total Labour	$281 86	.....	.....
													Total Supplies	89 165	.....	.....
													From Power Account (Drills)	31 20	.....	.....
													From Power Account (Pumps)	7 86	.....	.....
													Total	$410 085		
													Sunk 40 ft. 6 in., cost $10.125 per foot.			

TABLE VI.—FORM FOR RECORDING AND ANALYSING PROGRESS IN SHAFT SINKING. BY COURTESY OF JOHN E. HARDMAN, ESQ.
The same general form serves for records of stoping, with slight change in the headings of the subdivisions.

office, which will facilitate this operation. This ticket should be checked weekly by the clerk in the office from the stores book.

All classes of articles and materials used about the works, needless to say, should be kept in stock. It is perhaps a somewhat open question whether costs, such as office expenses, umpire assays, advertising, express and mint charges on bullion, insurance, taxes, and legal expenses, which bear a varying ratio to the output or amount of work done, should simply be shown separately under the head of General Expense Account (as is usually done), or whether, as Mr. Hardman advocates, they need to be distributed in the cost minute book to different branches of Mine, Mill, or Capital Account, against which they may be properly chargeable; but, no doubt, if a manager will take the trouble to carry it out, this is really the proper plan.

In the same way, whilst management, pumping, hoisting, etc., should unquestionably be shown separately, it is undoubtedly true that, in order to show accurately the actual cost of doing a certain piece of work, a proper proportion of such costs should be charged in the cost minute book, or general costs ledger, against the various jobs into which they enter as items of cost. This can be done in several ways, as described by Mr. Hardman, of which he gives an illustration in his valuable paper. Another form given by the same author, reproduced in Table VII., page 700, is an excellent example of how the power account should be dealt with and subdivided in the cost minute book; great laxity is usually shown in keeping track of this department, and such a system, properly carried out, frequently results in making possible economies previously unsuspected.

Tally should be kept of every pick or hand or machine-drill pointed, to determine the cost per point and charge the right amount to the different jobs in progress underground and on the surface; whilst all fuel sent to the shop must be weighed and charged against it, as also steel and other material requisitioned from store, which, after it is used, is credited to the shop and debited to the account for which it is employed. Stock should be taken at least once a year of all iron, steel, etc., on hand at the smithy, when it can be rounded up and weighed.

A carpenter or machine-shop account should be kept on the same lines as that of the blacksmith's shop.

Where ore is trammed from a mine direct to the mill, such tramming-charges are figured on the basis of the total number of tons trammed, and generally come under the head of Milling or Surface Expenses; but where ore is shipped, its shipment may be charged under mining-costs.

DAY.	Oil, Vulcan.	Oil, Black.	Oil, Lt. Engine.	Packing Rubber.	Packing Flax.	Packing No. 1.	Packing No. 2.	Tallow	Cotton Waste.	Compression Grease.	Fittings.	Tools.	Candles.	Lamp and Lantern Globes.	Lead, Red and White.								Fuel Coal, Tons.		LABOR.
1	....	....	5	....	....	....	....	3	....	....	....	....	....	....	....	....	....	....	....	....	....	....	Stock.	....	$6 25
2	1	....	....	....	..	....	....	..	10	5	....	....	....	....	....	....	....	....	....	....	....	....	12.25	....	6 25
3	..	....	....	....	....	....	....	..	..	..	....	....	..	....	..	....	....	....	....	....	....	....	.....	....	6 25
4 S	....	....	....	....	....	....	....	..	..	..	....	....	..	....	..	....	....	....	....	....	....	....	20 5	....	6 25
5	....	....	....	....	....	....	....	..	..	..	....	....	2	....	..	....	....	....	....	....	....	....	.....	....	3 00
6	....	1	....	....	....	....	....	4	....	..	....	....	....	....	....	....	....	....	....	....	....	....	12.0	....	6 25
7	1	....	....	....	....	....	....	..	....	..	....	....	....	....	....	....	....	....	....	....	....	....	.....	....	6 25
8	....	....	....	....	....	....	....	..	....	..	....	....	....	....	....	....	....	....	....	....	....	....	.....	....	6 25
9	....	....	....	..	....	....	....	..	....	5	....	....	....	....	....	....	....	....	....	....	....	....	.....	....	6 25
10	....	....	....	....	....	....	....	..	..	..	....	....	....	....	....	....	....	....	....	....	....	....	18.8	....	6 25
11 S	....	....	....	....	....	....	....	..	..	..	....	....	....	....	....	....	....	....	....	....	....	....	.....	.....	3 50
12	1	....	5	....	....	....	....	....	....	..	....	....	....	....	....	....	....	....	....	....	....	....	.....	.....	6 25
13	....	..	....	....	.	....	....	3	....	....	....	....	2	....	....	....	....	....	....	....	....	....	10.5	.....	6 25
14	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	.....	6 25
15	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	.....	.....	6 25
16	....	....	....	....	....	....	....	....	..	..	1 chisel 1 wrench	....	....	....	....	....	....	....	....	....	....	....	.....	.....	6 25
17	1	....	....	1¼	3	2½	....	....	....	..	1) 1½ union 14 ft 1½ pipe	....	..	1	1	....	....	....	....	....	....	....	16.7	.....	6 25
18 S	....	....	....	....	....	....	....	....	....	..	....	....	....	....	....	....	....	....	....	....	....	....	.....	.....	4 75
19	....	....	....	....	....	....	....	4¼	10	5	....	....	..	....	....	....	....	....	....	....	....	....	.....	.....	6 25
20	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	18.2	.....	6 25
21	....	1	....	....	....	....	....	....	....	....	....	....	2	....	....	....	....	....	....	....	....	....	.....	.....	6 25
22	1	....	....	..	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	.....	.....	6 25
23	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	.....	.....	6 25
24	....	....	5	..	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	12.4	.....	6 25
25 S	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	.....	.....	3 50
26	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	.....	.....	6 25
27	1	....	....	....	....	....	....	3¼	..	5	....	....	..	....	....	....	....	....	....	....	....	....	20.6	.....	6 25
28	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	.....	.....	6 25
29	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	.....	.....	6 25
30	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	.....	.....	6 25
31	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	.....	.....	6 25
Totals	6	2	15	1¼	3	2½	....	18½	20	20	.....	.....	6	1	1	....	....	....	....	....	....	....	141.95	.....	$183 50
Prices	.49	.25	.38	.30	.25	.34	....	.07	.06	18	.....	.....	.12	.10	07	....	....	....	....	....	....	....	27.20	St k	.....
	2.94	.50	5.70	.375	.75	.85		1.295	1.20	3.60	.22 1.96	.25 1.75	.72	.10	.07								114 75 tons $3 40 390.15		

310 hours	Pumping.	Charge Pump account	$ 39 52
554 "	Compressing.	" Compressor account	332 66
638 "	Milling.	" Mill account	157 19
		" Hoisting account	79 08
			$608 45

Supplies	$21 60
Fuel	390 15
Labor	196 70
Total Cost	$608 45

Labor = $183 50
Add Sup'ce = 13 20
$196 70

TABLE VII.—SUBDIVISION OF THE POWER ACCOUNT. BY COURTESY OF JOHN E. HARDMAN, ESQ.

By keeping a shift-record, a manager is enabled to arrive at the production per single shift, or per man at work, which is often highly instructive. To do this, the shifts expended on a given piece of work in a given period (say a week or month) are divided by the unit of work (such as tons produced, feet driven, or tons trammed) which they represent, and compared with results of a similar kind; and as Mr. Hardman points out, "a cardinal point in the subject of costs is the ratio between producers and consumers, producers being labour which is *directly* engaged in producing material from which revenue or income is derived, such as men stoping or developing, whilst consumers may be classified as those who simply handle the valuable material produced, without increasing its amount, such as trammers and all surface men. The smaller the proportion of consumers, the more profitable the mine; the larger this proportion gets, the less the profit becomes. The percentage of cost which labour and other items, such as fuel, water, explosives, etc., bear to one another at different mines in the same district, and in one district as compared with another, is another point to be looked into and studied, in order to ascertain the cause of differences that are frequently found to exist and to determine whether they are preventable or not.

As the manager must oversee building and machinery plans, surveying, etc., a well-equipped drawing office is indispensable to a large mine. Drawings of different kinds should be classified and kept apart, and a record of each drawing, which should be distinguished by a number, should be kept for reference. The planimeter and slide-rule are time-and-labour-saving appliances that can be and are employed with advantage in well-regulated large offices, not to mention the pantograph or eidograph, for reducing or enlarging scale drawings. Solar-printing is a useful and economical auxiliary in this department, for copying tracings. I will only add that all surveys, assay-plans, etc., should be brought up to date monthly, and a tracing should be sent home quarterly, if not more frequently.

The manager's concern with contracts, specifications, etc., must be still more summarily dismissed. All I need say is that it frequently embraces legal business, which at times necessitates the assistance of a solicitor, and in some cases requires knowledge and consideration of various systems upon which work is paid for—such, for example, as the lease or tribute-system, extensively used in Colorado and elsewhere.

In conclusion I would say, as I took occasion to remark some years ago in discussing the cost of milling in different localities, "*The ef-*

ficiency of the general management is the master-key to the success of a mining undertaking." If the workman is to demand and obtain high wages in the future, it will only be rendered possible by employing high-class technical and business skill in the management and conduct of operations, so as to take advantage of every practical and scientific improvement which tends to cheapen the aggregate cost of production, and in duly proportioning wages in all departments to relative efficiency and usefulness, whether in respect of mental attainments or manual dexterity. Unskilled labour, in fact, can no more hope to compete with skilled workmen living in comfortable circumstances (although highly paid) in a field such as mining, where skill is essential, than the skilled workman can expect to banish cheap labour from a field where nothing but slight manual effort and intelligence are needed.

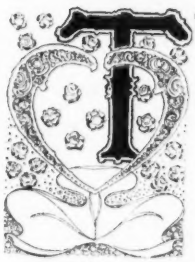
The only certain proof of economy in administration is the ratio which the cost of handling and treating a given tonnage of ore bears to the percentage of gold or other valuable product saved, when compared with the cost of doing so under similar mining conditions elsewhere; gross cost, which is governed by local wages, rates and numerous other circumstances, is no criterion whatever to gauge it by.

Discrimination in employing the right man and the proper material or machine in the right place is the pivot on which management turns; although it amounts in the former case simply to the knowledge when it will pay to put on an extra man at a profit, and when to knock one off the pay-sheets; where to employ a mechanic, and when to make shift with a labourer. Where you have to deal, as you must in any large undertaking, with the three different factors of brain, manual skill, and muscle, it is not less ridiculous, for instance, to place a man who may be an adapt in cobbing ore in charge of a mill, with the salary of a first-class mill-man, than to put the latter to run a stone-breaker, at the wage of a labourer.

No one can doubt that the question of mutual and fair adjustment of profit, as between the two co-important trade factors of capital and labour, so that both can exist in harmony, is fast becoming the problem of the hour, as it certainly will be of the next century; and the chief prop on which the future of the miner and the capitalist alike depends is in the application of technical science, and the careful selection of the men and machinery employed about a mine, with a view to cheapen production as much as possible.

COST KEEPING; A SUBJECT OF FUNDAMENTAL IMPORTANCE.

By James Newton Gunn.



TO say that cost keeping is a subject of fundamental importance seems to be offering a statement which, of any that might be presented to a manufacturer, is most trite. Any manufacturer will agree with such a brilliant generalization. Having discharged his whole duty by agreeing with the proposition, he becomes a member of that large majority into whose hearts has not entered even a suspicion of what is involved in really finding costs.

Cost finding is not merely the work of an accountant, no matter how competent he may be. It is the work of an engineer, supplemented by the best accounting knowledge that he can command. The engineer in turn must be possessed of an executive faculty to such a high degree that he shall be able to create and administer an organization, which not only finds, but shall continue to find, costs. Having found the costs, this executive must be possessed of a sufficiently broad knowledge of that portion of the industrial world to which he is related to be able to use the information which he has, and to preserve such an organization as will insure facts for each succeeding month or year being presented in like manner with those first compiled, so that he may receive the full benefit of comparison. For costs have no value except in comparison, that action may be directed by experience.

Therefore the first essential of a system of cost keeping is that the work of the organization shall be up to date, so that the facts presented may be used before the conditions shall have so changed, or the interest of the executive in the particular matters under consideration shall have so far waned, as to make the information of no value.

The second great essential for effective cost keeping is predicated

The term "cost-keeping" is misleadingly narrow. The science which forms the foundation of intelligent advance in the economy of production deserves a more fitting name—deserves recognition as itself a specialised branch of engineering effort. Mr. Gunn draws clearly the outlines of the province of the "production or industrial engineer." The concrete application of his specialty to particular works forms the literature of which THE ENGINEERING MAGAZINE is a great current library. A concentration of this literature, prepared by Mr. Gunn and other leading specialists, will be found in "The Complete Cost-Keeper," just issued from THE ENGINEERING MAGAZINE PRESS.—THE EDITORS.

by the first. Manifestly, to insure prompt returns, the general organization of the factory, or whatever the industrial undertaking, must be so complete as to prevent delays in the presentation of the general results. This matter of general organization is so essential to cost keeping that cost keeping really becomes a detail in the larger question of factory or industrial organization, which question must be solved before any solution of the other can be made. Frequently I have had occasion to liken a fully-equipped factory to a man well-trained for his particular duties, skilled in many things, having a multitude of duties to perform, each member of his body properly developed, working in harmony with the other members, and all controlled by the general executive, the intellect. In a large factory the manager, the intellect of the establishment, must have a system of records, machines, and men, which serve respectively as his nerves, bones, and muscles. Any derangement of the nerves means a failure to communicate properly to the muscles the will of the intellect; therefore this nervous organization of the factory must first be created. The very term "factory or industrial organization" indicates what must be done. There must be:

1:—A clear definition of the departments of business, that similar work and similar functions shall be grouped in one department.

2:—A positive definition of duties of each department and its relation to the general business.

3:—A clear fixing of the responsibility and a willingness to have responsibility rest with the heads of the various departments.

4:—Scrupulous care to communicate the various wishes of the chief executive, through the proper channels, that the responsibilities fixed may be preserved and each department limited to its particular functions and for the specific purposes of cost keeping.

5:—A harmonizing of the commercial accounts, that is, the representative accounts of the business, with the general scheme which is to be followed in the factory-accounting or cost-keeping department. To be more specific: the representative accounts in the private ledger should be such as to present certain statistics as to aggregate amounts of various classes of indirect expense and the direct expenditures, so as to show the relations between these various classes and to provide means for checking the results or the accuracy of the detailed costs elsewhere determined. The plan for the commercial accounts must include closing monthly the loss-and-gain statement of the various operations of the business.

6:—A proper head to the department of cost keeping, who must be as much engineer as accountant and capable not merely of compiling

figures, but of using the information when the facts are compiled; for the end of cost keeping is cost reduction. This man must be so efficient that he may be depended upon by the highest official of the company and he will naturally be high in the councils of the latter. Much condemnation of really efficient cost keeping comes from the inability or failure to use the information which is extant. A man who fills such a position will have no sinecure.

The third essential to accurate cost keeping is the positive determination of final results which are to be secured. A seeking from the start for definite ends will frequently eliminate much unnecessary work in the developing of any plan, and prevent the expanding of one portion of the work beyond its due limit and the treatment of another portion in a superficial manner. For illustration, let us assume a representative establishment in which the gross annual expenditures are $600,000, of which $200,000 is spent for direct or productive labor, $200,000 for direct materials, and $200,000 for all indirect expenses of the business. These proportions it will be found are essentially correct. Most schemes of cost keeping will devote, in such an establishment, about $6,000 to all of the work incidental, directly or indirectly, to getting costs; and of this amount about $3,500 will be devoted to tabulating information about the labor, or one-third of the gross expenditures; and $2,500 to material and indirect expenses, or two-thirds of the gross expenditure; and yet the direct labor is the portion of the expenses which can be least readily reduced and about which the natural conditions under which the expenditure is made will make it most easy to get accurate information.

The criticism of the eventual usefulness of the information finally secured may thus determine the amount desirable to expend, or necessary to expend, in getting these results. It may often be found that a predetermined plan to give costs in extreme detail will be abandoned when examined from the standpoint of determining how much detailed information the executives are able to use, leaving to some future date the development of the system so that when the detailed information is secured it will be used. A clear definition of a plan of cost keeping will have the further advantage of making it possible for the chief executive to insist on the preservation of the organization from any modification without his authority.

It would be quite proper to expect of a system of cost keeping:

1:—Final costs; that is, the costs of completed units of the product at the door of the factory, and final costs in which to these factory costs are added all commercial and selling costs.

2:—Partial costs; that is, costs of certain component parts of machines, or costs of steel or brass at certain stages of their production.

3:—Comparative costs; that is, between the costs of one period and another, and the costs of like articles as produced in different plants under control of the same corporation.

4:—Costs by operations; that is, the direct labor costs, so that it shall be possible to change from a day basis of remunerating labor to some form of a piece-work basis. These costs by operations should likewise be comparative from one period to another, in order to show the results of modified methods of manufacture, modifications in the system of remuneration, or the results of combination of two or more operations into a single operation.

5:—Indirect costs by classes and groups weekly; by this it is intended that a definite schedule or classification of the various indirect expenses in any undertaking shall be made; and that costs compiled under this classification shall be the basis for considering any modifications from the general scheme in administration of the factory, the modification of the plant, or the modification of such indirect-expense operations as shall effect a direct saving. The result of such tabulation of indirect costs should give the basis for accurate distribution of indirect expenses upon the direct factors of cost, in some manner that shall be more equitable than the old and common method of arriving at a percentage relation. The present practice of using this percentage basis of distributing indirect expenses very frequently includes the practice of using one expense rate for a period of a number of years, and the frequent disregard of the variations of expense rates throughout the various departments of the plant.

Some of the results of an effective system of cost keeping, in addition to enumerating costs as above, should be that it should show how large an investment in material is permissible, and, combined with effective factory organization, it should keep the efficiency of that investment as high as possible.

The fourth requisite of an efficient system of cost keeping lies in such an organization of the factory as will centralize under one storekeeper the control of all material expended by the manufacturer. Very many manufacturers will argue that because their material is not liable to depletion by theft, from the lack of its value to an individual, they may safely figure their costs on the basis of a theoretical schedule of the material that should enter into any given unit of their product. While in some cases this may be true, it is a fair rule that such a plan fails to account for loss in waste or scrap that occurs in every manu-

facturing operation. It also fails to account accurately for the material which forms, in the majority of cases, an important item of indirect expense. The plan of having a general store-keeper does not necessarily mean that the material under his control shall actually be stored in one place, but may in fact be distributed as the exigencies of the business demand. A general store-keeper will, in addition, be an important factor in cost reduction, through obviating losses and delays arising from not having the proper material on hand for the completion of a given order, and he will largely prevent over-stocking of material and the consequent unnecessary investment in materials.

The last of the principal essentials to an effective system lies in the completeness with which any scheme is executed. Many general managers feel that it is sufficient to take the report of a trusted lieutenant as to why their scheme of cost keeping is not efficient. Cost keeping is of such paramount importance that this is not a thing to be entrusted to any assistant, however, excellent he may be. Some of the most satisfactory systems of costs that have passed under my notice have been valuable because of the most excellent organization and the degree of careful administration given by the chief executive, and yet some of the systems that produced these satisfactory results were by all laws of criticism cumbersome, inefficient, and inadequate. Experience has borne witness to the converse of the proposition, and there exist several notable examples of carefully-worked-out plans for cost finding which are worse than useless, because the real heads of the business have delegated their administration to a clerk, or a fairly good commercial accountant, or to a general manager, who is valuable, not as a manufacturer, but as one skilled in marketing the product. To expect in establishing a scheme of factory organization and costs that its results will be forthcoming within a few months will be wrong, as the best plan can be evolved only after many months, and perhaps years, of painstaking development and modifications of the general scheme. It is essential, further, that the one having charge of costs shall have full access to the most private information of the company, else in his indirect expenses the costs will give results which are at best approximations, and no matter how close, will be inaccurate.

It is impossible, within the limits of this article, to do more than offer general principles, and therefore to deal with mechanical devices or methods for the scheme of records is impracticable, even if it were desirable. It is undesirable because no example which would embody specific forms and methods could be even broadly suggested, as the conditions which surround the cost problem in different industrial un-

dertakings, even if the product or object is similar, are so many and various that the same scheme would in no way be satisfactory or applicable. In general, however, this has been proven; that for quickness in presenting results, the elimination of duplicate records, the prevention of errors in transcription, and the insuring of dealing with original records, the card system is best.

A proper system of costs must be depended upon to furnish the information on which shall rest the judgment of the chief executive in determining the remuneration of the employee. Our best students of the labor problem believe that four out of five of the instances in which difficulties have arisen in acute form between employer and employee, could have been avoided had the employer been properly equipped with real facts regarding the productiveness of the individuals on his payroll, and had he used this information for the establishment of such a basis of remuneration as would have rendered to the individual an increasing return per day in exchange for increasing productiveness.

Labor has constantly suffered from the ignorance of capital concerning its own ventures. Capital has likewise so suffered, and while all manufacturers agree that a knowledge of the operations of the business is of paramount importance, they are inclined to scrutinize out of all relative proportion those expenditures required to give them these results. They further are slow to enter into a scientific investigation of the facts presented in their own business, becoming impatient of final results and refusing to recognize that each manufacturer must, to a large degree, in solving the problem of costs, solve the problem of the economic relations of the investor and the laborer. This problem yields only to long pains-taking study. I believe so thoroughly in the fundamental importance of cost keeping and factory organization as to proffer this suggestion: that while engineering today has, as its recognized representatives, civil, mechanical, mining, and electrical engineers—those who deal rather with processes and mechanical methods—yet there exists a science which only awaits the creation of a literature to have its own existence recognized as a new department of engineering. Our various industrial organizations are successful directly as their executive or administrative heads have made a study and application of the principles of that science, which may be termed the science of production. The successful manager has himself become a member of this existing, but as yet unrecognized, engineering profession. The discovery, study, and collation of the facts, and the enunciation and application of the principles of this science, are the work of the production or industrial engineer.

THE MECHANICAL AND COMMERCIAL LIMITS OF SPECIALISATION.

By J. Slater Lewis.

WHILST it is quite evident that there must exist definite commercial and mechanical conditions beyond the limits of which specialisation will cease to be profitable, it is not easy to define these limits in so many words on account of the extreme complexity of the question. Moreover, specialisation being essentially a process of evolution, it is not at all certain that its tendencies can be controlled, or that its developments will always be on the side of even-handed progress.

The mechanical limitations, whilst absolutely hinged upon commercial considerations, are much more simple and capable of formulation than the latter. Given quantities sufficient and a steady demand, mass-production follows as a matter of course. This observation suggests, however, that a systematic treatment of the subject would include consideration not merely of the natural conditions favouring specialisation, but also of conditions artificially brought about with the same object consciously kept in view. In other words, the conditions limiting specialisation will be best studied by an examination of the conditions favourable to its development.

Mechanically considered, the subject has very sharply defined boundaries. On the one hand, there is the condition of things obtaining before repetition work was known, when every single part of every single machine had to be separately made and individually fitted, and on the other a mechanical millenium, in which all possible ele-

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An American, viewing the works of a leading Swiss manufacturer of machinery, commented upon the great range of work—marine construction, steam engines, hydraulic appliances, electric motors, general machinery. "Would you not manufacture much more cheaply if you specialised on one or two of these lines?" he asked. "Possibly," was the reply, "and lose far more through the fluctuations of demand in our comparatively circumscribed market. Now, if steamboat building is dull, our electrical work may keep us running full-time; if both are slack, factory and mill engines are likely to furnish abundant work. Steadiness of business means more to us than ultra-specialisation." The question whether this steadiness should be secured by extending the range of work done in the factory, or the range of the market in which the factory product is sold, is an engrossing one, and one which must be specially determined by the conditions of each special case. Mr. Slater Lewis reviews the ultimate considerations entering into the problem.—THE EDITORS.

ments of a machine will be the separate productions of highly-specialised industries, and the task of the machine designer will be to combine these, and the work of the machine builder will be confined to purchasing and putting them together. It will be recognised that this degree of specialisation has already been nearly realised in connection with architecture and building. Yet there was once a time when the builder shaped as well as used his materials.

Although in engineering work we are as yet far from such an extreme development as is here assigned as the ultimate limit, it will yet be permissible to claim that we are at least well launched on this path. Many of the elements of mechanical combinations are already so highly specialised that it does not pay the engineer to produce them for himself, under any ordinary circumstances. Gear wheels, shafting, hangers and fittings, certain kinds of nuts, bolts, and screws, lubricators, pressure gauges, and practically all electrical appliances may be cited as examples. It is a truism to say that this class tends to increase.

The influences which tend to such increase cannot be called mechanical. They are almost wholly commercial—questions of extent of and the access to markets. Of course, the demand in the first instance arises from a degree of uniformity in the use of any given appliance, but this, though a technical, is certainly not a mechanical question so far as the production is concerned. On the other hand, the actual production of any mechanical element on a large scale with a consequent advantage in price, uniformity of product, or other hitherto unattained excellence, may create a demand where none existed before, and this is, in fact, the usual history of new specialisations. By creating a demand is here meant forcing the general adoption of some one standard type to the exclusion of local varieties.

As regards the mass production of any one comparatively simple article, there are, then, practically no mechanical limitations. The controlling considerations are technical adaptability capable of extinguishing, by balance of advantages, all slight individualities of design; all the rest are pure matters of commercial wisdom and opportunity.

In the case of machines, on the other hand, or of any contrivance consisting of a number of organic parts and having a range of sizes or powers, mechanical considerations begin to weigh upon us. Just as the manufacturer of a single specialised article tries to produce a design which will supersede as many small varieties as possible, so the maker of a range of machines will strive to have as many parts

as possible common to several machines. But this standardisation is, perhaps, the least of the problems involved. Its advantages are so obvious that it is not a point likely to be under-rated. The question of the special machine, designed and built for production of one element only of the whole, is a far more debatable one.

The mechanical limits of specialisation in any given product will evidently have been reached when no further standardisation of parts can be attained without sacrifice of technical efficiency, and when all the machines in use are special machines each producing one article, and one only, more cheaply and satisfactorily than it could otherwise be produced. The critical point is the determination, for any given piece, when it will pay to devote a machine wholly to its manufacture when such machine will have to stand idle for part of its time. The problem of adopting a machine that can be filled with work is an easy one to adjudicate upon; to know just when to employ a machine that must perforce lie fallow for more or less doubtful periods demands a fine judgment.

The commercial considerations limiting specialisation are much more numerous and important than the mechanical. The ultimate appeal in all these matters is to the arbitrament of competition. The reason why specialisation has such surpassing interest for the engineer to-day is because the engineering industries are at that particular phase of evolution in which specialisation presents the most vigorous weapon of competition available. To competition by specialisation there is no possible answer but equal or further specialisation. It is in the nature of things a temporary or passing phase, yet with the most rapid progress possible, its possibilities will not be exhausted in our time. But where rivals are already trying to occupy the same field in which there is not room for both, the superiority will obviously remain with that one who has the balance of conditions in his favour. Now, it is much more probable that mechanical conditions will be equally balanced than that commercial conditions will be. For this we have to thank the spread of technical education, the chief use of which is in averaging technical conditions.

By technical education is not meant, however, the set curriculum of the technical school. This provides merely the groundwork on which further progress may be built. The true technical education of the engineer lies in the free interchange of experience by the medium of the technical press, the papers read before learned societies, with the discussions they elicit; the throwing open of works to the expert on his travels, and kindred methods by which the news of

progress circulates throughout the world. The effect of all this is undoubtedly to average up the standard of practice the world over, and to make purely mechanical conditions equal between intelligent competitors in the same special line.

As regards commercial conditions there is no such opportunity of availing one's self of the results of others' experience. The manufacturer who has discovered a new channel for the disposal of his productions does not call upon his rivals to admire his cuteness. On the contrary he keeps all such matters in the profoundest obscurity that he can manage. In some cases precautions almost bordering on the grotesque are taken to keep the knowledge of the destination of orders confined to as few officials as possible. The result is that notwithstanding the cult of the technical school, the real arena on which the survival of the fittest is fought out is and will remain the commercial one. The bearing of this on the question of specialisation is obvious. Sufficient grasp of commercial conditions to know when it will pay to sink capital for the purpose of forcing the market's consumption of any article is the possession of very few. The reward of success is very great, but the risks of faulty judgment are far heavier than in the case of an ordinary enterprise. One of the principal reasons for this lies in the stereotyped character of the productive elements of high specialisation. A plant which is arranged for production of some specialty, for which after all there is not sufficient commercial excuse, becomes a very heavy clog on its possessor. The commercial limitations are thus seen to be very serious and rigid, and to deal successfully with them demands exceptional study and mature consideration of all possible contingencies.

Thus far the question of rivalry as between equally-placed competitors has alone been considered. There is, however, a much wider view than this which needs attention. ¶It has already been said that the secret of successful specialisation lies first in the existence of a possible market large enough to absorb the proposed production, and secondly in properly-directed efforts to obtain access to it. Now, though there is only one natural market, whose limits are coincident with those of the civilised portion of the world, the effect of political divisions is to convert that simple area into a very patchwork of subdivisions. A fiscal map of the world would be a most interesting study, and perhaps might be regarded as a monumental example of the shortsightedness of humanity at this particular stage of its development. But however mistaken the policy of high walls and jealously-guarded boundaries, there seems little prospect of its modi-

fication at the present time; we have therefore to consider the effect of these artificial barriers as they actually exist.

A study of the actual influence of the establishment of the German zollverein and the iron wall of the American tariff on the power of competition in foreign markets, by reason of the wide base free from outside interference which this policy of exclusion provides, would be a most interesting one to make. The nursing of nascent industries by a protective tariff is at least a process too frequently justified to be called in question. That the State adopting it loses more than it gains is one of those fetishes of political economists that seem to owe acceptance to ferocious assertion rather than demonstrated reality.

Without, however, losing our way among these bye-paths of theory, we may regard the matter in a light that is at least suggestive In the matter of specialisation it is fairly evident that a manufacturer operating within the limits of a tariff zone will be enabled to produce from the very first on a large scale, and to this extent will be in a more favourable position to compete with his surplus production in foreign markets. The British manufacturer, on the other hand, has no such home preserve in which to gather strength. He has from the first to try and occupy his own market, already over-run by the surplus production of his foreign competitors. Any remaining energy he may have left is to be devoted to competition with those same rivals in neutral markets, with all the disadvantages which production on a smaller and more uncertain scale gives as a handicap.

It is not always the conservatism of the British manufacturer that is to be blamed for his hesitation to adopt methods that are confessedly giving the American the cream of this particular class of work. The range of the British and the American manufacturer is too often so dissimilar as to make the methods of the one of doubtful advantage for the other. How many American and how many British manufacturers have access to the markets of both countries? The answer to this question, if thoughtfully considered, will explain a good deal of the mystification which has grown up around this vexed subject of discussion.

It was suggested at the outset of this article that specialisation, regarded as a growth or course of evolution, might not necessarily always prove to be on the side of progress. We have an example of this in the reproach which was at one time universally and is to-day occasionally conveyed by the utterance of the phrase "machine-made." Ugliness and monotony were considered inseparable from machine productions. Time proved that this was not really so, but the com-

plaint was true at that period. Although a matter of æsthetics is somewhat outside the province of the engineer, a parallel line of argument will sometimes hold good. Specialisation leads essentially to uniformity, and uniformity means the starving out of individuality. Stereotyped conditions may thus eventually be set up which will react harmfully on progress. To watch for this danger does not, however, fall in the province of the specialiser; he is not able to look to ultimate effects, for his interests are of necessity centered in the present period of transition.

Emphasis

Whilst it is true that specialisation leads to a gradual transfer of operations from the hands of the engineer to those of the manufacturer, it must not be lost sight of that the manufacturing of engineering articles is somewhat different from any other. These articles are not in themselves prime objects of consumption like silks or condensed milk. They are themselves only factors or organic elements in productive processes.

It is evident from this that subdivision into separate trades or industries will have a limit imposed by technical considerations, beyond which it will not be possible to pass. The ultimate subdivision being in itself an organic piece, it will be necessary for the manufacturer to keep constantly in view the technical conditions subject to which it functions. This will always prevent subdivision going to such extreme length as we find in the Birmingham trades, wherein there are manufacturers devoting the whole of their attention to the production of a single class of article, and that in perhaps only one or two varieties. It is evident that the manufacturer who is a specialist in "pepper-caster tops" is not oppressed with any very serious technical conditions of use which have to be permanently kept in mind.

Far otherwise, however, is the case of the specialiser of mechanical appliances, even of the simplest and most widely-applicable class. It is not for him to rest and contemplate his labours when he has equipped and started his plant, though it be only for shaft couplings. In an article of ultimate consumption there is no progress to keep constant reckoning of (who ever improved a "pepper-caster top" or a thimble?) but in the case of even a shaft coupler, the technical investigator may at any time emerge from obscurity, with a series of experiments, tending to show that present principles of construction are all wrong—bringing fame, indeed, for himself, but only trouble and vexation to the specialiser.

The most obvious cases of one kind of specialisation are those undertakings which deal entirely with appliances for one special pur-

pose, such as laundry machinery, spinning machinery, printing machinery, etc. These are, however, not specialised in the sense in which the word is used in this article. It will be readily seen that this is not productive, but only technical, specialisation. There is, however, in such businesses a fair field for the introduction of a partial productive specialisation in the way of a carefully arranged standardisation of parts. In cotton-spinning machine building this possibility finds its fullest realisation on account of the great number of precisely similar elements, by aggregation of which the machine comes into existence. This kind of specialisation is chiefly of advantage in a commercial sense, inasmuch as the repute of a firm for the technical efficiency of the plant it instals may easily over-rule any mere questions of price. It is not, however, specialisation in the productive sense at all, and must indeed be considered rather to operate in the other direction, by its tendency to allow the field to be ruled by other than considerations of price.

To sum up this brief glance at the conditions under which specialisation progresses: we find that while mechanical limits proper can hardly be considered as entering into the question, so slight must be their influence compared with other ruling factors, the technical and commercial limitations on the other hand are much better defined and recognisable in their influence on possibilities. This influence is not always harmonious; on the contrary, the conditions are very intricate. They may shortly, but very imperfectly, be summed up as follows:

Specialisation in the productive sense will be technically possible when the articles to be produced are already organically simple elements, the technical function of which is well understood and not likely to be modified by local conditions of use. The illustration adopted above, though by no means exhaustive, is a very good one for the purpose—a common shafting coupling.

In some cases some sacrifice of actual conformity to local requirements may be suffered in favour of a standard article, by reason of its price or reputation. A second stage of technical limitation is where a range of appliances for a common purpose allows the engineer to arrange a series of parts or elements common to several or all of the productions. It is evident that this is only productive specialisation by a stretch of the definition.

But this must not be supposed to imply that the article itself must of necessity be of simple construction. On the contrary it may be a complex machine, such as the latest type of turret lathe, a screw-making machine, or a "linotype" machine. Each of these is an organic-

ally simple element. So is a dynamo. But a loom is not. The difference lies in the consideration that the lathe, the screw-making machine, and the dynamo each subserves a number of different ends, according to the organism of which they are ultimately destined to form part. The maker does not require to know this ultimate destination; it is a matter of indifference to him whether the articles are installed in a locomotive works or a South American arsenal. Within their limits they will perform a wide range and serve many ends. The loom will only weave carpets or cloth, as the case may be. Its range is limited to that. That this is not merely an academic distinction may be seen if we consider the first as general, and the second as particular tools. Technically, therefore, the problems limiting the specialisation of the first are much less burdensome than those of the second. It might be better to classify the loom as an independent element, of which the conditions of use are so complex, depending upon the nature of the material to be worked up and the exact class of product desired, as to render a general technical solution of the underlying problems almost impossible, the effect being to limit the scale of production, and to imply the triumph of local conditions over possible uniformity.

Where the technical conditions of the problem favour a uniform product, and hence specialisation, it does not follow that the latter is commercially possible. The visible demand for a certain article may be insufficient to warrant a large outlay. There may be no guarantee that changes of tariff will not unfavourably affect present markets. There may be doubt whether the product will so far commend itself to the tastes of users as to supersede their practice of making it for themselves. There may be a doubt whether the home production is on a sufficiently large scale to withstand the competition of more favoured specialisers working on the basis of a secured home market, whose productions are expected shortly to overflow into this.

That the tendency towards specialisation will have a certain course to run seems certain. But that the final condition of industry will be the existence of a number of separate undertakings, each confining itself to one narrow and special field, is not so certain, although that stage may have to be passed through. It seems thinkable that a contrary current may begin to set in when this stage is fully reached. A process of synthesis or aggregation may ensue, for, other things being equal, it is evident that commercial advantage is on the side of the man who can supply two allied appliances on competitive terms, where his rival can supply only one.

SHOP ARRANGEMENT AS A FACTOR IN EFFICIENCY.

By H. F. L. Orcutt.

GOOD work can be done in bad shops, and bad work can be done in good shops. In these days of high-pressure competition, however, and under the increasing demand for good work, manufacturers must employ every possible facility which reduces the cost of production and assists in maintaining a high standard. Not the least of these facilities is the modernly-designed shop. At no very distant date, the manufacturer who does not possess shops specially-designed and equipped for a particular purpose will be left behind in the commercial race. The steamship, telegraph, and railway are rapidly breaking up trade monopolies which for years have been the main support of antiquated shops. Industries are decentralising and, at the same time, specialising. Only those manufacturers who are the fittest will survive. Those who would erect up-to-date works have now to consider problems never dreamt of by the builders of the majority of existing shops. Model plants are rare in any country, but America leads in respect of numbers, both in regard to what has been done and in the interest taken in the matter of further improvement. It is surprising how many new shops are being erected in Europe with really very little in them that is advanced, and it is still more surprising how many manufacturers are still working in absolute ignorance of the demands of the times concerning the best plans of shops, the selection of equipment, and commercial and social conditions.

The design of a shop, or of works, is mainly affected by the nature of the equipment necessary for turning out the product. Due consideration must also be given to organisation, both commercial and

Mr. Orcutt's articles on Machine-Shop Practice in Europe and America, which appeared in THE ENGINEERING MAGAZINE, Jan.-Aug., 1899, will be remembered with keen pleasure by all readers. For comprehensive grasp of the entire subject and instant seizure of the essentials of the best practice, they stood apart as a master-work in the literature of industrial engineering. In this article, in brief outline, Mr. Orcutt applies similar broad views to the solution of the problem of shop design and arrangement. It is a solution which conceives of the shop itself as a great tool that must take its shape and inter-relate all its parts according to the work it is to turn out, and operate as a unit through the perfection of its technical and commercial organisation.—THE EDITORS.

technical, and the time has passed when any manufacturer could afford to erect workshops with little or no regard for that all-important factor, his work people.

In treating the matter under consideration, the term equipment includes all machinery, tools, gauges, auxiliary plant, power plant, means of transportation, and shop fittings. The term technical organisation refers to the arrangement of departments and the positions they occupy; and commercial organisation to a system of keeping track of the progress of work, cost keeping, and accounting. In speaking of accommodation for work people, it is intended to include all appliances, fittings, and details of construction which affect the comfort, health, and contentment of the workers, as well as any systems which educate or instruct. All of the above must be considered by the designer of the modern shop, for the simple reason that all are factors which directly affect the cost and quality of product.

The shop may be considered a huge machine, of which the equipment and men are the moving parts. These are so arranged to work one with the other that the product, passing through, reaches the finished condition with the least expense in the desired state of finish or accuracy.

The functional details are many, and, of course, vary with the nature of the article to be manufactured. Whatever the article is, however, it must be recognised in constructing the modern shop that the specialist has come to stay, and the days of the "Jack of all trades" are numbered. Instead of planning shops in which either locomotives or bicycles can be made, works must be designed which are best suited to the economic production of one class of work. This is a necessity for cheap and good manufacturing, and also conducive to the constant improvement of the article to be produced.

Again, in the engineering world, at least, the era of cheap equipment is passing by. Machines and tools must be selected, and methods of manufacture must be determined upon, which are known to produce the best class of work, all being as far as possible interchangeable. The determination to follow this principle very largely influences the manner in which work must be subdivided, the departments that are necessary, and how they are placed relatively to each other; it also largely affects the selection of auxiliary plant, gauges, and standards. We still have a long and weary pilgrimage to the Mecca of interchangeable work—the pilgrimage started by the mechanic who made the first labour-saving tool. As we go on, however, gradually converting nearly every article of food, shelter, and comfort into the machine-

made product, not only must every machine or part be, of a necessity, of great accuracy, but all operations must be backed up by scientific knowledge, and exact standards must be made use of to take the place of guess work and hand fitting. This is the only method by which the combination of good quality and cheapness can be brought about. Otherwise we must rest content with the cheap and nasty, and only expect the best quality when accompanied by a high price.

How many makers of the marine engine, the loom, spinning machine, bicycle, or locomotive are independent of the "fitter" to give the final "touch" which makes them work, instead of knowing exactly the limits to which parts must be made and then keeping within these limits with the aid of proper standards? How many foundry men know the chemical composition of their cupola mixtures? If some old faithful servant, who has broken pig iron for thirty or forty years, at last retires, whole works are often disorganised with bad castings until a new hand "gets the hang of the thing." How many makers of fine cutting tools know the temperature at which steel oxidises? It is high time that we stopped guessing, and planned to manufacture in our shops with machines which will turn out accurate work, tested by gauges—the limits of which can easily be determined—and that we began to know the chemical and physical properties of all the material used. The skilful workers will then be small in number and their field will be confined to the making and maintaining of plant instead of to producing the article itself; the main body of workers in the modern shop will become little more than machine attendants.

To counteract the evils which may arise from this condition of affairs, the modern shop must provide for the comfort, health, contentment, education, and recreation of its employees. This is an economic necessity as well as a business enterprise. It is curious how little the captains of industry have learnt from the captains of war, yet there are lessons that have been before us for centuries. It is ancient and modern history that the best-equipped, the best-trained, the best-organised, and the best-fed soldiers are the *most efficient.* Manufacturers go on with miserable equipment and no organisation, make no effort to train or educate, and think anyone positively mad who suggests that the matter of food and comfort of employees should receive any consideration. Still, they grumble at the discontent of the worker, his lack of intelligence, the restrictions of trade union, bad workmanship, high wages, and lack of interest in improvement. Whether fighting or working, men are the same; they are assisted by good equipment, improved by good management, made more efficient

by proper surroundings and comforts, and work more intelligently when properly trained. This is neither philanthropy nor socialism; it is business.

Is it more to the profit of the employer to have dirty, ignorant, unhealthy, and discontented than clean, intelligent, able-bodied, and contented workers? Is it more to his interest to erect shops in which everything is ignored that might be desired by intelligent, progressive men, than to have shops so planned and fitted that they will be attractive to only the best class of employees? The most-productive and skilful workers will seek shops which are clean, warm, ventilated, and well lighted, which have the best sanitary arrangements and facilities —which are conducive to comfort and cleanliness—where it is thought worth while to instruct in the best methods of manufacturing and designing, where machines and tools are provided which assist in doing the best grade of work with the least manual exertion, and where a management prevails which not only expects men to be interested in doing good work and in reducing costs, but, in return, shews some interest in cultivating a spirit of suggestion and criticism, and in giving rewards for improvements. Works planned in which the above items were looked upon as worthy of a place in the organisation, would have little to do with the Factory Acts or trade-union restrictions.* I believe 80 per cent. of the so-called labour troubles are due, particularly in Europe, to the fact that so many of the masters build shops and run them absolutely ignoring the comfort, interest, and welfare of the most-important factor of their business—their workmen. Judging by some individual cases which I know, the worst offenders in this respect are those who continually grumble at the shiftlessness and the lack of interest and intelligence in workmen.

Most employers of labour seem to be incapable of comprehending that there is a social question which has a direct effect on the cost of their product. As far as this is concerned Europe is much worse-off than America, on account of peculiar "class" divisions which exist; this disadvantage will continue unless affairs grow worse in America (and there is strong evidence to show that this is becoming the case), or a social revolution takes place in Europe. This point is emphasised for the reason that it is not usually recognised that America has the advantage of working under relatively favourable social conditions.

In planning new works, it is usual to determine first the form, size, outline, and construction of the building or buildings, and then to

* It is highly interesting to see how important a place is assigned, by a clear-sighted observer and practical manager of international experience like Mr. Orcutt, to the labour policy set out in detail by Mr. Patterson, pp, 577-602, this number.—THE EDITORS.

make internal arrangements conform to fixed surroundings. The obviously-reasonable way is to follow exactly the opposite method. Give due consideration to all the requirements of the manufacturing in view, decide on the necessary departments, their areas and relative positions, and let the building assume what form it will, instead of at once settling on having, for instance, a large central aisle and galleries, one or two floors, wings, or what not. The departments of a shop should be broadly considered somewhat as follows:

1. Are any separate parts, like the receiver of a rifle or the hub of a bicycle, to be manufactured in sufficient quantities to warrant putting down complete plants for the production of those parts?

2. Must the parts to be manufactured be made in such small quantities that they would all be put through the same departments?

The majority of engineering establishments must probably follow the latter course. Whatever the arrangement is to be, modern engineering requirements dictate clearly how machine work is to be subdivided, economic production necessitates the specialisation of operations, and transportation gives the cue as to the positions of departments. In calculating areas, it should not be forgotten that floor space for parts in process of manufacture is just as important as floor space for the machinery itself. The designer of a shop who prides himself on crowding machinery into a small space should pocket his vanity and alter his tactics, or perhaps find an appreciative employer in a shop where the management believes in having one foreman in charge of as many men as possible (up to 150, I have known), or in having one man controlling all kinds of machines—lathes, turret machines, planers, millers, grinders, etc.—as well as doing his own inspecting, instances of which are also not unknown to me.

In shops where heavy work is done, it will be found most economical to make distinct divisions of heavy and light work, as totally-different conditions are necessary for cheaply-finishing light and heavy parts. "Stores" form an important factor in modern manufacturing and are a make-shift in all the older works; they should be arranged in three classes:

1. Rough material.
2. Material partly finished.
3. Finished products.

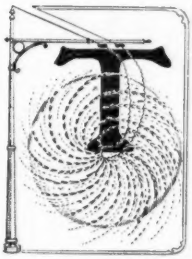
There is at present a healthy recognition of the importance of having auxiliary plant in the way of a well-equipped tool room and a proper equipment of standards, limit and working gauges; this has been a much-neglected item in European shops. The old-fashioned

manufacturer who is still living in the past of hand methods, the "fitter," and primitive machinery, is the last to appreciate this innovation, which is an absolute necessity to the modern shop. I have known many cases where the failure or indifferent success of a labour-saving tool could be traced directly to the absence of a good tool room and the talent which should accompany this important department. Labour-saving machines and tools made to turn out the best class of work at reduced costs, rapidly degenerate unless the means are at hand for constantly regenerating. The accurate lathe, the universal milling machine, the universal grinding machine, the shaper, and the cutter grinder are as necessary to the modern plant as the forge and grindstone were to the old-fashioned shops, where the greater part of the work was performed on simple machines, aided by hand tools. Tool stores with up-to-date small tools and gauges should not be forgotten. If the shop is large enough, it will be found advantageous to provide for these stores in the several departments. The selection of tools and gauges must not be made in a too-niggardly spirit; many European manufacturers have yet to learn that tools are of as much importance as machines. The success of labour-saving accurate machines is largely dependent on working them in connection with properly-made tools and fixtures, and in keeping these adjuncts in the best working condition. In many shops there is little or no provision for storing and distributing tools and fixtures.

The thread which knits the whole fabric together is the system of transportation of parts. Too often in designing new works this part of a modern equipment is left to work out as best it may, when in reality it should be studied from the beginning. The building should be planned so that systems could be installed by which labour is reduced to a minimum and every minute of time saved. I should think few works can afford to neglect to consider the very complete system of light-railway appliances which are now obtainable. Fast-running electric cranes and pneumatic hoists seem to be the most-efficient means of handling parts which cannot be lifted by hand. The principal items concerning the structural features of the works are the design of floors, ceiling for overhead rigging, heating and sanitary arrangements, and windows. Each item is worth considerable attention, as all affect the economy of manufacture. It has been my intention to mention only those points which it seems should be considered by those who would erect really modern works, in which every thing should be embodied which aids in economical production. Details of equipment and organisation have been purposely avoided.

APPLICATIONS OF ELECTRIC POWER IN ENGINEERING WORKS.

By Louis Bell.



THE electric motor at the present time does not have to formulate a reason for its existence in connection with engineering works in order to prove its adaptability to the mechanical problems that there have to be solved in so many and intricate ways. The motor has taken its place as one of the every-day, hard-working, steady-going, reliable pieces of apparatus that is to be counted on and used with the same freedom that a pulley or a block and tackle would be applied in its appropriate place in the constitution of a modern industrial plant. The question now is not whether the electric motor is a sound and conservative method of furnishing power, but whether it is particularly adapted to the purpose in hand. If it is so adapted, its use needs no explanation; if not, some other solution of the particular problem attacked must be sought. In this respect the situation as regards electric motive power has developed itself in a highly satisfactory manner during the last few years. Those who were in the electrical art near the time of its beginning remember well the anxious eyes that were cast on the early electric motors—how the pros and cons of the queer, new apparatus were discussed industriously and how, for years, motors were looked upon somewhat askance, as allied to things not altogether comprehensible and possibly of ill repute. All this is changed and now the manager of the modern works, in the organization of the tremendous industrial mechanism which he has under his hand, depends on engines or water

Dr. Bell's most interesting paper, beyond its direct value, affords striking evidence of the existence of Industrial Engineering as an exact science, having fixed principia accepted by all its professors. Thus in his treatment of the adaptation of electrical drives and the use of portable tools, he displays the idea developed by Mr. Orcutt—(pp. 717-722) that the whole works should be regarded as a single great tool, of which separate machines are the moving parts; in his reference to the tendencies of intensified production, he harmonises with Prof. Higgins (pp. 568-576); in his reference to the uses of electrical appliances to increase the workman's comfort, he endorses the position taken by Mr. Patterson (pp. 577-602) and Mr. Orcutt.

Dr. Bell rightly dignifies the part electricity has played in the economy of modern productive engineering. It is peculiarly his field. THE ENGINEERING MAGAZINE has in preparation similar reviews of the kindred services rendered by the sister-agencies in the application of mechanical power—Compressed Air and Hydraulic Methods.—THE EDITORS.

wheels or compressed air or electricity, as the particular occasion and the particular work require.

As a rule, the general uses of electric motive power in such operations are in one of the following four directions:

First:—To secure by the utilization of transmitted power a cheaper motive power than could be secured from a localized power plant, either steam or electric.

Second:—To distribute motive power, from whatever source obtained, more economically than it can be distributed through mechanical means.

Third:—To take advantage of the singular mobility which electrical-power distribution permits, in order to utilize to the fullest the portable machine tools of various sorts which are now coming into extensive use.

Fourth:—To adapt the well-known art of electric traction to the oftentimes onerous task of transportation within the works.

To these may be added a few instances of electric current used as current for certain specific purposes not connected with motors.

The first count is something apart from the immediate purpose of this paper, the advantages of power transmission having no particular relation to the general problem of the utilization of electric power in modern industries. Such transmitted power may be, and has been many times, utilized with great success and with a very gratifying degree of economy. In fact, one of the earliest power-transmission plants at high voltage, now in operation for seven or eight years, was in the great industrial works of Escher, Wyss & Co., near Zürich, Switzerland, where three-phase current at 14,000 volts has been the main motive power of the works for the period just mentioned.

The second form of utilization of electrical energy is, however, one of great importance in many directions. For all large industrial purposes there is a great and usually somewhat erratic demand for power, both in the various departments of any given works and, from time to time, in each department. A great manufacturing establishment does not ordinarily run under the conditions of load which may obtain, for instance, in cotton-mill work, where most of the machinery is in use all the time and the demand for power is singularly steady from minute to minute as well as from day to day. The philosophical basis of the economy of electric power under such conditions lies in the fact that where power is distributed by purely mechanical means over a considerable area, the losses in transmission are practically independent of the load, and hence at light loads, either on particular machines

or in particular departments, these losses are relatively and necessarily severe. In electrical distribution the losses in transmission are proportional to the load, and being at all times less than the losses in the mechanical transmission over any reasonable area, are particularly slight at times of light load, so that the average economy of distribution is sufficiently high.

It is well-known—too well-known to admit of doubt or be a proper subject for discussion here—that the total efficiency of an electric-distribution system, from the brake horse power of the prime mover to the power delivered at the shafts of the motors, usually ranges from 75 to 80 per cent. at full load, and should not under ordinary circumstances fall off more than say 5 per cent. at one-third to one-half load.

Now, inasmuch as the average losses in the shafting in miscellaneous shops for metal and wood working are usually between 30 and 50 per cent., and sometimes more, the character and amount of the saving to be obtained by the application of motors becomes sufficiently obvious. In an establishment taking, for example, one thousand horse power in miscellaneous machine work, the losses on average load in the distribution by shafting from the single prime mover would rarely be found to be less than 50 per cent. The average loss with the electrical distribution would very seldom be found to be over 30 per cent. This means a clear margin of 20 per cent. in the saving of power—200 horse power out of every 1,000; at $50 per horse power per year (which is not an excessive estimate on the cost of 10-hour or 12-hour power obtained from steam under such conditions) the saving would amount on this basis to not less than $10,000 per year—an economy which promptly and vigorously speaks for itself. The saving in this amount is less than would be found in many cases which have come under my notice, and could be trusted to pay for the installation of the electrical plant in a comparatively short time.

In point of fact, it is safe to say that in the transmission of so large an amount of power as that just mentioned from a single prime mover, the losses in shafting and belting would be considerably in excess of those just given, and the saving in an electric drive would be correspondingly larger. As a matter of practice, it usually happens where the aggregate power is so considerable that a single prime mover is discarded in favor of several or many engines, placed in various parts of the works and each adapted in size to its particular purpose. This substitution too often "changes the place but keeps the pain." A 1,000-horse-power engine can be operated, as is well-known, at vastly better economy than twenty 50-horse-power engines; the

former will operate on 15 to 25 pounds of steam per horse-power hour where the latter will require from 30 to 50 pounds. It is not particularly advantageous, except in the item of wear and tear on shafting, to substitute a loss in the engine cylinder for a loss in the shafting, since the coal pile suffers about equally in each instance.

In certain types of small engines often used in practice the steam economy is very much worse even that that just mentioned. Tests made within the last few years on the auxiliary machinery of warships have shown some startling examples of inefficiency. Tests, for example, made on the cruiser Minneapolis showed that the average consumption of steam per indicated-horse-power hour in the auxiliary engines was nearly 120 pounds, while even the best of these engines showed a consumption of 70 to 75 pounds per indicated-horse-power hour. Similar results have been obtained on numerous recent warships, both in the United States and elsewhere. Of course these conditions would not often be found in a manufacturing works, although there are few large establishments employing numerous engines in which such conditions would not apply to some of the engines installed. Steam pumps, when used, are particular sinners against economy, often taking from 100 to 300 pounds of steam per horse-power hour; so notorious has this fact become that even in large electric stations it is often found advantageous, purely from the standpoint of economy, to use motor-driven pumps, taking current from the main generators, rather than to pipe steam even a few feet and use it in the steam pump. Wherever it is possible to use electric motors coupled directly to individual machines, the power consumption required for mechanical operations can be diminished is a very remarkable degree. Of course, in cases of very small individual machines so much is lost in the efficiency of the motors that a group drive—a single motor operating a number of smaller machines—is more economical than the use of separate motors; but in the larger classes of machine tools, such as are continually in use in all large engineering works, direct-connected motors, causing no waste of power nor any running expense when not actually needed, are each year coming into more extensive use and are steadily raising the average efficiency of motor installations.

Fig. 1 is a type of recent practice in this respect, and consists of a 7½-horse-power motor geared directly to a very large milling machine. The actual power used in cutting away metal by a tool is not generally large compared with the total power taken to operate the gears through which the machine functions, and this loss in the direct-

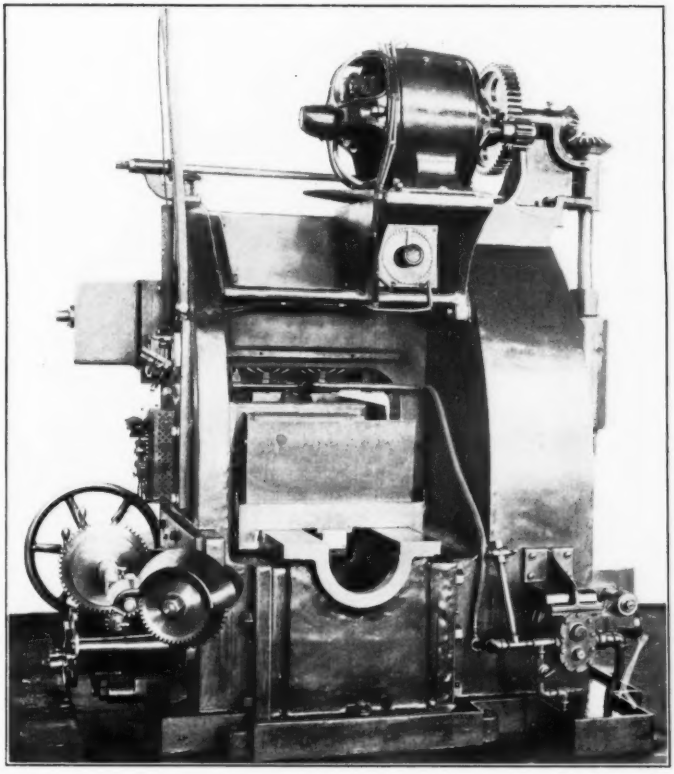


FIG. 1 LARGE MILLING MACHINE DRIVEN BY DIRECT CONNECTED 7½ HORSE-POWER GENERAL ELECTRIC MOTOR.

coupled milling machine is the only material loss and is cut off while the machine is stopped, while in ordinary practice, where such a milling machine is driven by such a shaft actuated by a loose pulley and belt shifter, the shafting loss (likely to be as large as the whole useful power employed in the machine) goes on whether the machine is in full operation or not. Fig. 2 is another excellent example of a large direct-driven machine, being a squaring shear for heavy plates driven by a 5-horse-power motor. Here the momentary work is considerable, but the average work on the machine is not great and, again, all the power used is limited to the machine itself and not wasted on the transmitting shafting. Fig. 3 is a similar machine on yet larger scale,

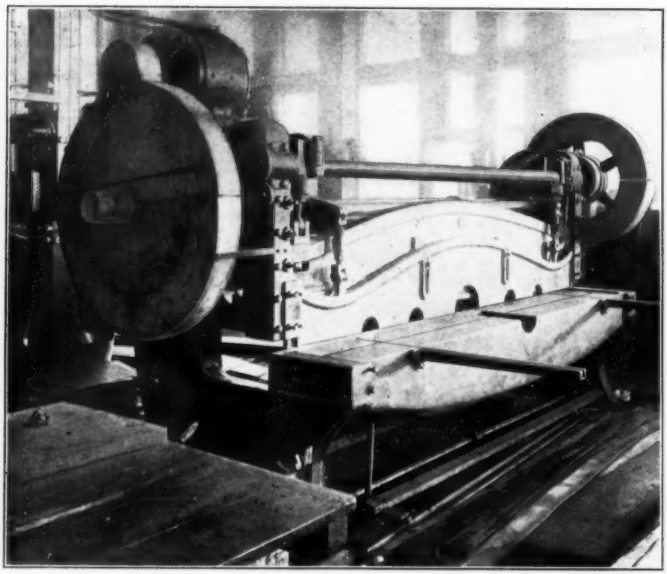


FIG. 2. SQUARING SHEARS FOR STEEL PLATES, OPERATED BY 5-HORSE-POWER ELECTRIC MOTOR.

General Electric Company.

while Fig. 5 shows practice of a more usual kind, in the use of motor-driven punch presses.

Fig. 4 is a good example of similar methods applied to wood-working machinery, being a 5-horse-power motor directly-connected to a planing machine. In machines of this class, owing to the high speed of the motors, considerable power is required even when running light, and yet, under ordinary conditions of shafting, the energy wasted in transmission is still a considerable portion of the power required at full load. Data on a machine of this type may not be uninteresting and may be tabulated, briefly, as follows:

Planer, running light	2,400 watts
Spruce plank, 12 inches wide, feed 23 feet per minute, maximum power	6,500 watts
Average power	3,400 watts
Minimum power	2,475 watts
This loss is substantially the friction load.	
Pine plank, 12 inches wide, feed 39 feet per minute, maximum power	7,200 watts
Average power	4,518 watts
Minimum power	3,225 watts

This probably represents an unusually favorable case in large machine work, the power actually consumed in doing useful work being at its maximum nearly three times the friction load. If the truth were known, it would be found that an efficiency of nearly 75 per cent., in a machine working even under the most favorable conditions, is very much higher than is usually found in large machine tools as they are worked day by day in actual practice.

The advantages in electrical driving, thus far indicated, have been merely those with respect to distribution of power—in other words, actual saving in the cost of motive power for the establishment; as a rule, however, such savings are smaller than those which can be made by a deft adaptation of electrical drives. In shops where very heavy work is done, careful managers are driven to the use of portable tools, since, in numerous instances, the tool is very much more portable than the object to be worked. In dealing with heavy castings and punch-

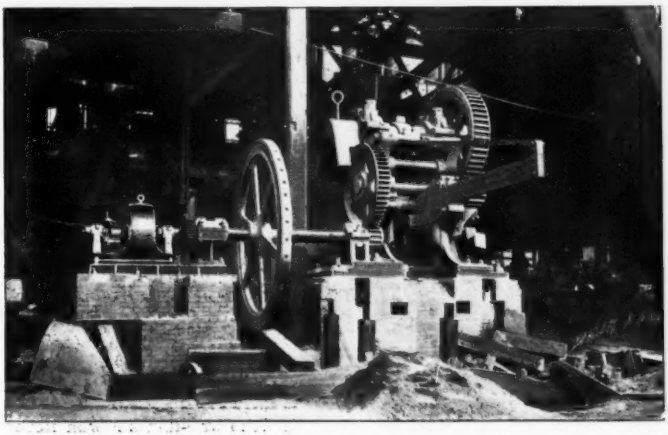


FIG. 3 ELECTRIC-DRIVEN CUTTING-OFF SHEARS, WORKS OF THE SHOENBERGER STEEL CO., PITTSBURG, PA.

Westinghouse Electric & Manufacturing Co.

ings, it is much more convenient to keep the work stationary and move the power than it is to adopt the reverse process, and for this a very large variety of portable drills and milling machines have been devised and put into use. Here again the advantage is one of convenience, of facilitating the necessarily slow progress of heavy work through the shops, and of enabling one process after another to be carried on while keeping the work stationary.

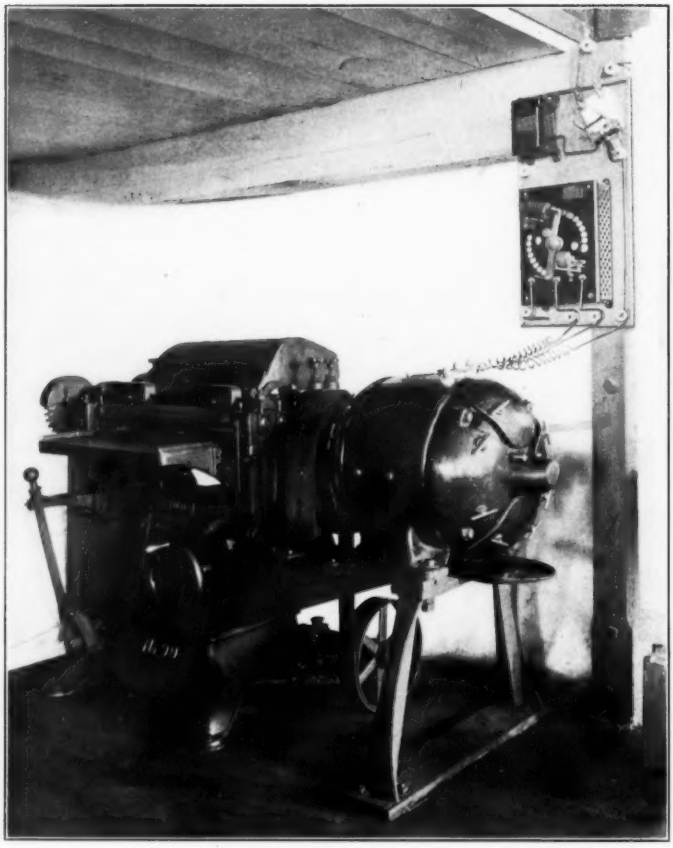


FIG. 4. ELECTRIC-DRIVEN PLANING MACHINE OPERATED BY 5-HORSE POWER MOTOR. General Electric Company.

Fig. 6 is a good typical instance of this sort of practice, now become tolerably familiar. It is a 2-horse-power motor driving a portable drilling outfit from a flexible shaft; the convenience of an apparatus of this kind needs no comment, and a considerable number of similar machines are at work, not only in the various engineering works, but in the Government navy yards, where they are found enormously convenient for executing repairs, as well as for facilitating structural work generally.

Speaking broadly, anything which facilitates the mechanical oper-

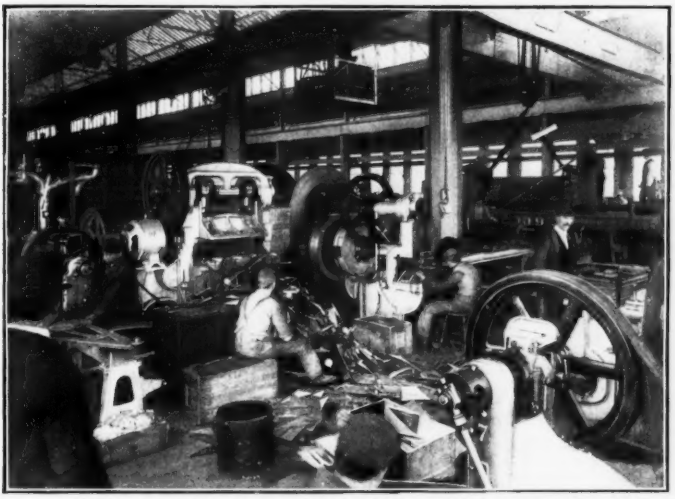


FIG. 5 PUNCHING DEPARTMENT OF THE BULLOCK ELECTRIC COMPANY'S WORKS, CINCINNATI, OHIO, OPERATED THROUGHOUT BY DIRECT-CONNECTED MOTORS

ations which have to be performed cheapens production. In the average manufacturing establishment it is not power that is the chief advantage of concern, nor material, but labor. Especially is this true in American establishments, where the relatively high prices paid for labor make economy especially necessary and where the relatively in-

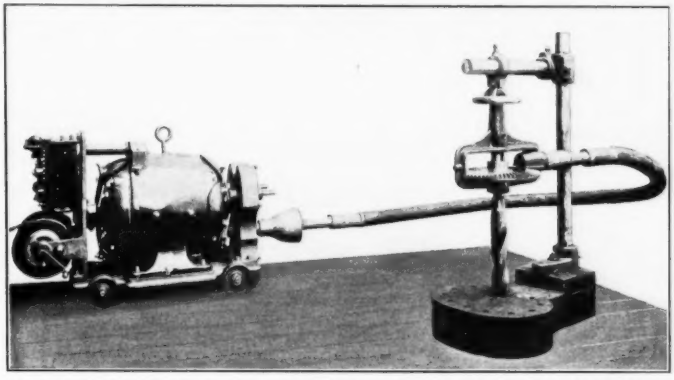


FIG. 6 A PORTABLE DRILL, DRIVEN THROUGH FLEXIBLE SHAFT BY 2-HORSE-POWER MOTOR.

General Electric Company.

telligent character of the labor makes labor-saving appliances possible. In the organization of a manufacturing industry, the finest opportunity for finesse on the part of the manager lies right here in the adaptation of his machine outfit to quick and ready work in turning out his product. A manufactory has an efficiency just as truly as a single machine. The more the product which can be turned out of an individual machine in a complete and efficient state in a given time, the higher the economic efficiency. This fact does not appear so clearly in a general manufactory as it does in some special lines in the industrial arts. The extreme importance of economizing the labor by labor-saving devices and of keeping all the machines going at full capacity all the time has come to be a part of the regular system of manufacturing, but in many works it is sadly neglected. The free use of portable tools economizes both in manual labor directly and also in the transportation expenses, which are no small item in many industries. Where the work invariably has to go to the machine, and where the machine cannot come to the work, the whole product has to move through the factory in a steady procession; if anything gets out of line, it either blocks the road for something else or is itself passed by and comes in late, to the intense disgust of everybody concerned. Engineering works are not like print cloth mills; they do not turn out a uniform product year in and year out, but make a very wide variety of things, differing not only in magnitude but in kind. This happens to be particularly true in electrical industries, with which I am especially familiar.

A large electrical-engineering works manufactures regularly, as part of its ordinary output, things differing as widely in size and character as wooden spoons, rat traps, and locomotives. Now for the efficient performance of the industrial machine, it is highly important that the wooden spoons, rat traps, and locomotives should be kept apart and not shuffled up together through any mistake in routine, and it is just here that electrically-driven tools come to the rescue; the tools can go the round of the work in a more or less regular procession, completing each single task in definite order, and their steady operation is only interfered with while the tool, and not the less mobile work, is being shifted. Along with such applications of electricity come the infinite variety of smaller applications which simply serve to facilitate the work of the men who are the connecting links in the industrial mechanism. Cranes and hoists and tramways all have their place in hastening the final end of getting the work through the shop promptly and effectively, without putting a single man's labor for an

hour in any place where it will not actually count in the quantity or quality of the efficient product.

An electrically-driven shop is singularly free from obstructions of any kind, and thereby is rendered easier to work in. Fig. 7, a motor-driven tool shop, shows how the complete abolition of shafting and belts clears things up and frees the space of encumbrances.

FIG. 7. AN ELECTRIC DRIVEN MACHINE SHOP, SHOWING THE CLEAR HEAD ROOM AND LIGHT AFFORDED BY THE SYSTEM.
Tool shop of the Bullock Electric Company, Cincinnati, Ohio.

In the category of electrical appliances which facilitate labor come such apparently trivial things as lights, fans, and blowers. I remember watching with amusement, a few years since, the course of operation in an electrical establishment where field spools were being wound. A long line of men were pounding steadily away at their tasks on a hot summer afternoon; one of them, midway the line, being of an inventive turn, had clamped to the countershaft in front of him four huge palm-leaf fans, which whirled steadily around for his exclusive benefit; the cheerful inventor stuck steadily to his task, winding away with the utmost placidity, while his neighbors on either side were stopping to mop the perspiration from their foreheads and growling to each other about the extreme heat. That one man saw his opportunity and will be a walking delegate some day—if he is not one already. Even such little things—in other words, looking out for

the comfort of the workmen by bettering the light and bettering the ventilation—tell in the ultimate output. It is not so much what each individual man is paid as it is what work he does that determines the economic efficiency of manufacture.

In all large establishments the transportation problem becomes serious, and there has been a steady increase during the past few years in electric tramways winding in and out of the shops and across the yards, to facilitate the distribution of raw material and the transportation of partly completed or finished product. The economic value of such tramways is at the present time obvious enough; they can be used in a particularly efficient way because, in any given factory, the general progress of material is a thing which can be to a certain extent predetermined so that the tramways can be put where they will do the most good, and the net result is the substitution of mechanical labor for hand labor, which in all except certain skilled trades has been proved an advantage a thousand times over. It is a saving of the same general type as that found by using a telephone system to connect the manager's office with the various departments. Three-quarters of the work of informal communication is now done by telephone, and the astute manager simply extends the process and transports his material as well as his wishes electrically.

For general purposes, no motive power has proved itself quite so convenient as electricity; there are certain types of tools, percussive tools in particular, which are operated to great advantage by compressed air, and certain types of lifts actuated by compressed air have proven immensely convenient. As a whole, however, the method lacks adaptability, and while we have heard continually of the vast advances which were to be made in the use of compressed air for general purposes, most of these have not as yet materialized. A volume might now be written on minor applications of electricity in the manufacturing arts, but the subject is one which can scarcely be treated in a single brief paper. Electric heating, welding, forging, and annealing all have their place in certain engineering works, and all are in successful operation for particular purposes. Every few months some new wrinkle in these minor uses comes to the front, occasionally rising to considerable importance, like handling steel plates and billets by traveling magnets, a fine example of which practice is shown in Fig. 8; many of them, however, simply amount to local adaptations for the solution of some particular problem, but one never knows when they may develop to a startling extent, even as the electric furnace has developed in the past few years.

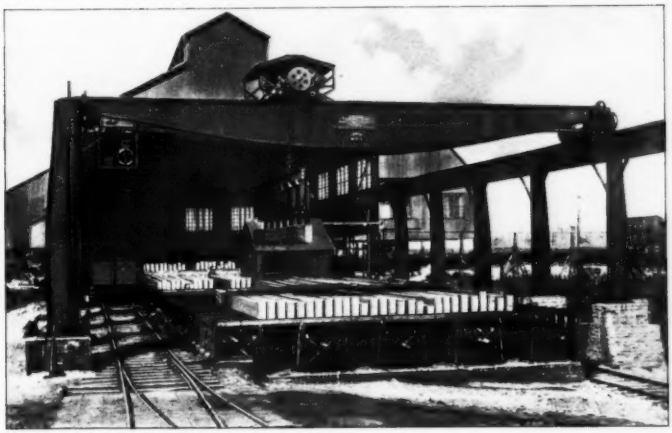
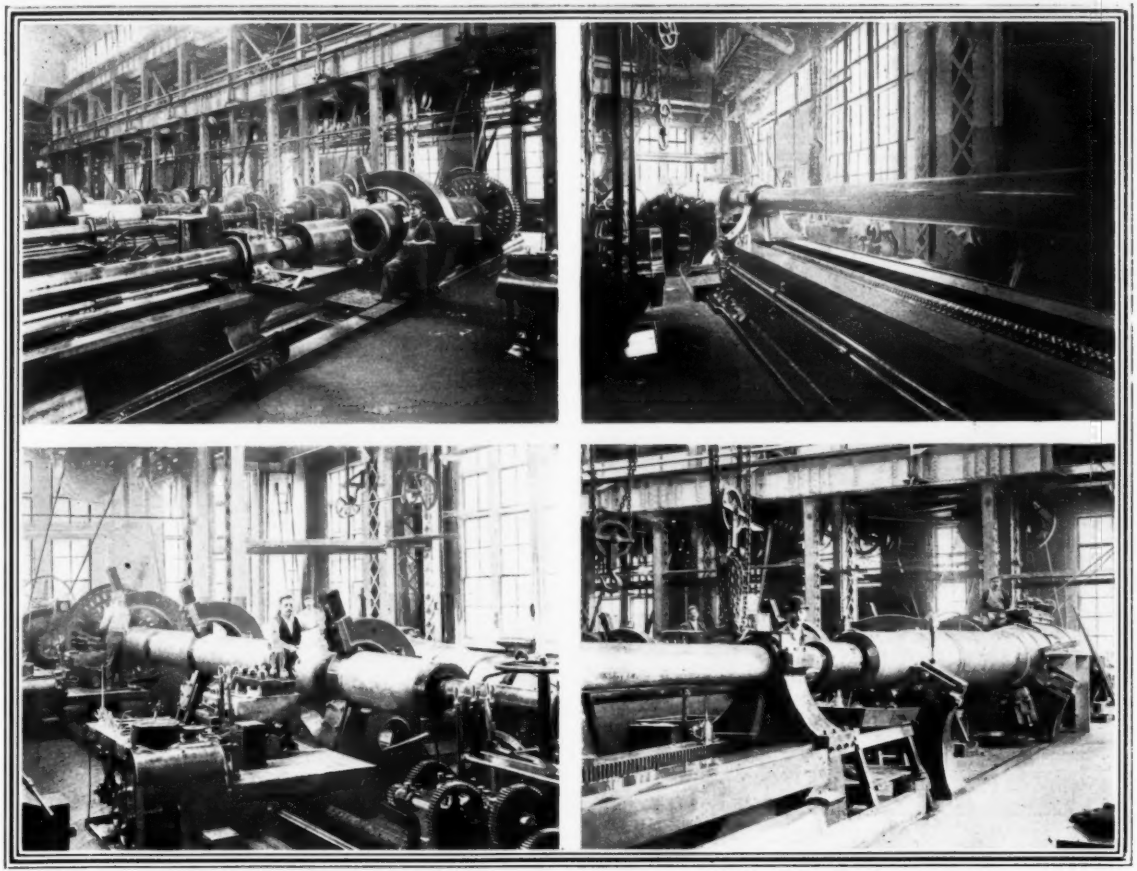


FIG. 8 ELECTRIC CRANE WITH LIFTING MAGNETS, NATIONAL STEEL COMPANY'S OHIO STEEL WORKS, YOUNGSTOWN, OHIO.

Each establishment has problems of its own to solve, and it is the task of the engineer to treat these problems systematically. To use electricity or compressed air where it will facilitate particular kinds of work, and to use a more direct mechanical process where the one now in use is intricate, leads to advantage; the main facts to be borne in mind by the manager of any industrial establishment with relation to such questions are these: First, that electric motive power and electrical methods have already proved their usefulness in many ways, some of these ways being such as will readily be adapted to problems that rise in almost any class of manufacturing. Second, that the most important single thing in administration is keeping down the total labor cost, and the trend of modern practice, based on sound experience, with relation to this particular economy, is towards reducing this cost—not by employing lower grades of labor or paying the workmen less, but by arranging the conditions of labor so that the work is done in a vastly more efficient way. American supremacy in the engineering arts has been gained through tact in the adoption of labor-saving devices. In the achievements of the Yankees in these particulars electricity has taken no small part heretofore. With the development in the past decade in electrical methods and apparatus, their application is likely to be of greater economic value in the future than it is now, or than the most enthusiastic partisan of electrical methods ten years ago would have cared to stake his reputation by predicting.

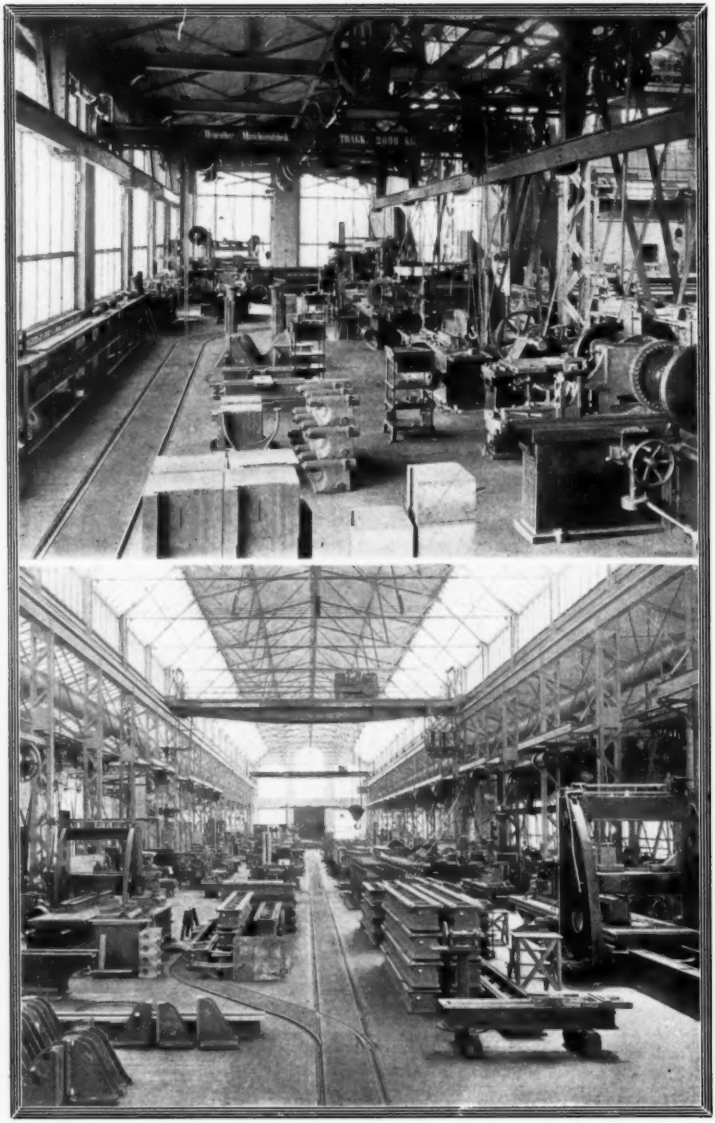


OPERATIONS IN THE MACHINE SHOPS OF THE UNITED STATES ARSENAL, WASHINGTON, D. C., U. S. A

The units handled are of the heaviest class, the engravings showing various operations in the making of a 13-inch gun, which is 40 feet in length, 4 feet in diameter, and weighs, unmounted, 145,000 lbs. The upper left-hand cut shows a row of heavy lathes; beside it is the rifling bar; below it is the operation of boring a 13-inch gun tube; the lower right corner shows the cutting of the rifling grooves.

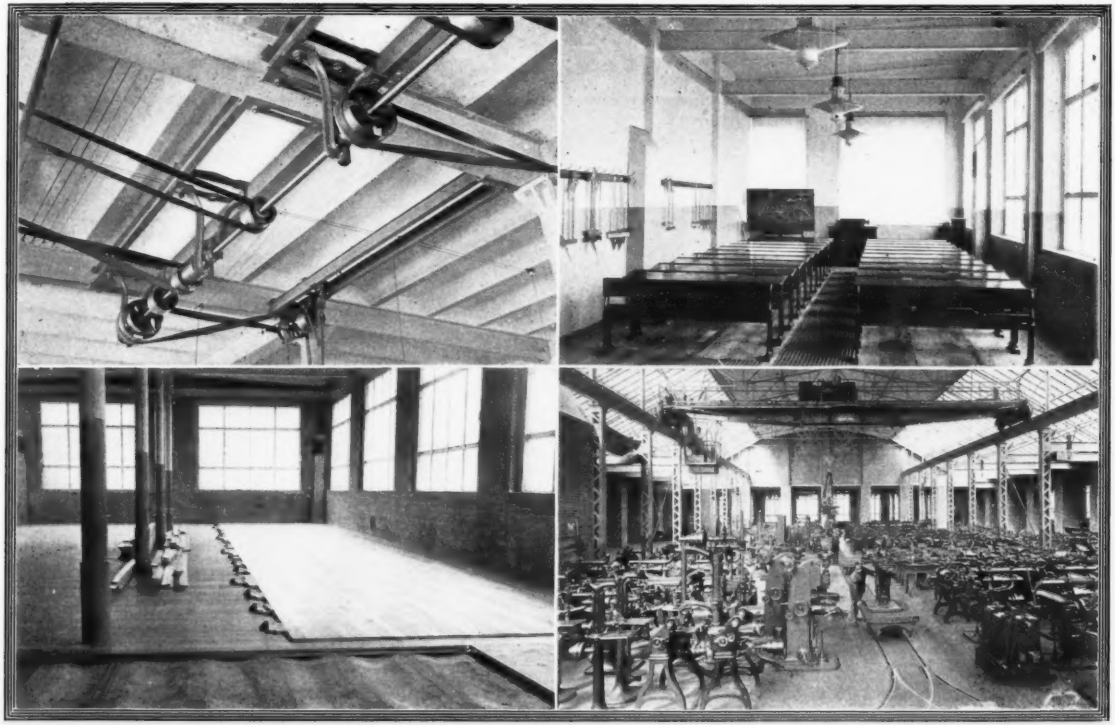
GENERAL VIEW OF MESSRS. HARLAND & WOLFF'S SHIP-BUILDING AND ENGINEERING WORKS, BELFAST, IRELAND.

At these yards were built the White Star fleet, including the Oceanic, the largest vessel afloat, exceeding in size the Great Eastern. Many interesting appliances were devised for the construction of this ship, among them the great gantry crane seen about the middle of the picture.



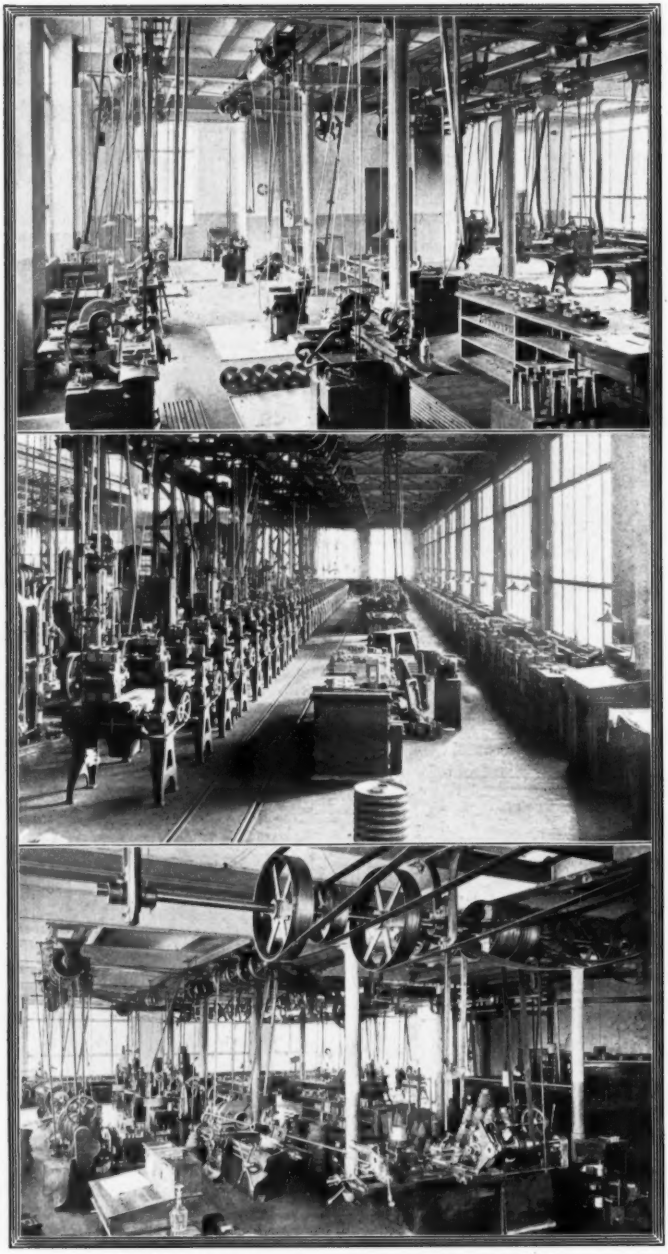
HEAVY-WORK DEPARTMENTS IN THE MACHINE SHOPS OF LUDWIG LOEWE & CO., BERLIN, GERMANY.

The works are designed, built, and operated throughout upon plans determined after exhaustive study of the best models of Europe and America. American practice predominates. The upper view shows the heavy milling department, the lower one the main machine hall for heavy work and erecting.



VIEWS IN THE LUDWIG LOEWE MACHINE TOOL WORKS, SHOWING CHARACTERISTIC FEATURES.

On the left is shown above the method of clamping countershafts and hangers to shop ceilings; below, is shown how the shop floors are laid—the top of hard maple, and the surface everywhere true. On the right, the upper picture is the school room for apprentices, where instruction is given free on the company's time; below is the machinery store house in the "Administration Building."



THREE DEPARTMENTS IN THE LUDWIG LOEWE SHOPS.

Top, grinding department—very largely used; middle, erecting floor for light machine tools; bottom, chucking department.

THE RADICAL POLICY OF SCRAPPING COSTLY MACHINERY.

By H. F. J. Porter.

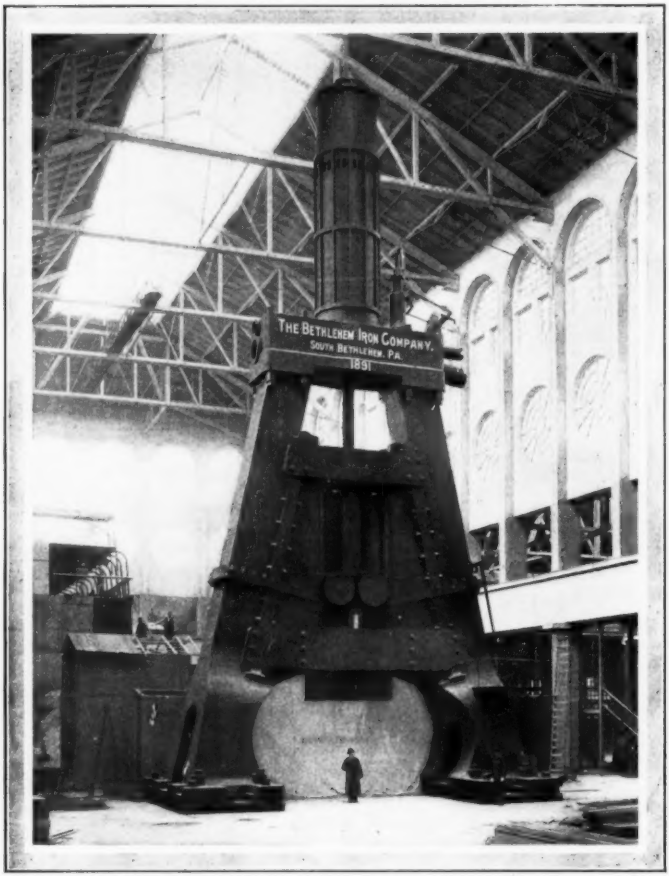
THE statement has been made by those whose province it is to analyze statistics that every year chronicles an advance in progress greater than was achieved by the previous two.

It is not our purpose now to discuss whether or not such a ratio can be sustained by proof, but what we are here concerned to note is the fact that the rate of advance which industrial and commercial development has attained during the last third of the present century has been far more rapid than that which characterized its movement during the first two-thirds. In fact, the change in the curve of progress is so pronounced at the beginning of the period first mentioned that it is impossible not to comment on the fact and to draw the deduction that at this point some occurrence of momentous import took place.

When we revert our mental vision down through the vista of the past, crowded as it is with countless happenings of vast importance, it is not difficult to discern the time referred to, nor to be impressed with the fact that the condition of affairs which then obtained was altogether unprecedented. Looking as far back as the line bisecting the century we find the times buried in empiricism. Men groped about in the dark, depending upon repeated trial and failure to find the way. Progress, led by error, halted from discouragement.

In 1862 the Land Grant Act was passed and the Technical School came into existence. The last third of the century began with only four of these schools in operation, but, though primitive in the extreme, their effect was being felt. The spirit of prejudice is most persistent where knowledge is most wanting, and in those days the inventions of men were ridiculed and looked upon with

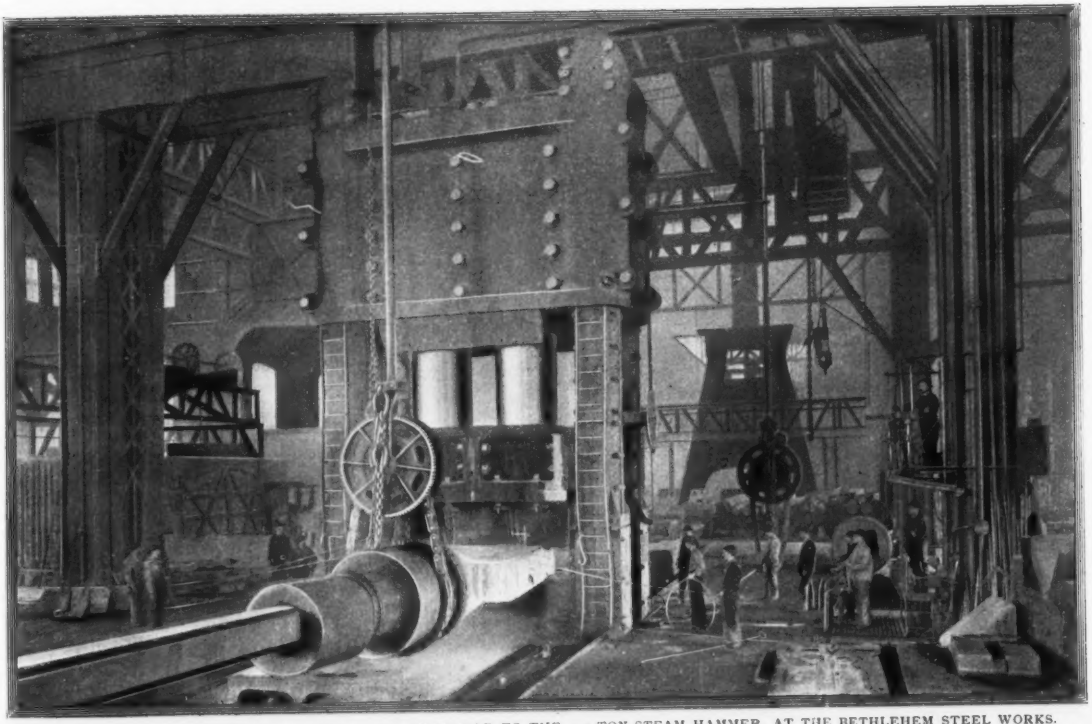
The practice which has come to be generally recognised as "American" has no more startling feature than the one here discussed by Mr. Porter—the instant discarding of any appliance, however costly, however sound it may still be, when a better is obtainable. To its critics it seems to be thinly disguised iconoclasm. To its adherents it appears the foremost element of success. It can be rightly judged only in the large—can be known only by its ripened fruits. And foremost among these stand such examples as the Carnegie and the Bethlehem steel works. To an authority intimately connected with the latter of these great enterprises is fitly committed the triumphant exposition of the overwhelming strength of the policy.—THE EDITORS.



125-TON STEAM HAMMER, SCRAPPED BY BETHLEHEM STEEL CO. IN FAVOR OF THE 14,000-TON HYDRAULIC FORGING PRESS SHOWN ON THE OPPOSITE PAGE.

This enormous tool—the largest hammer ever built—had scarcely begun its expected career of usefulness when it was superseded by a more efficient appliance. The view is taken from the full-size model exhibited at the World's Fair at Chicago, 1893.

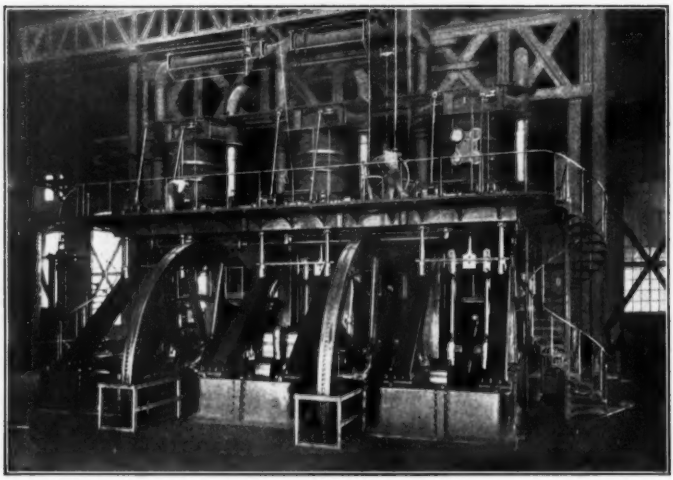
suspicion. Only the most rugged characters were strong enough to overcome the trammels that hampered them. Among such men were two whose great and originative minds and undaunted courage and persistence developed at this time the Bessemer process of making steel, of which it has been said that, with its introduction and the



THE 14,000-TON HYDRAULIC FORGING PRESS, SUCCESSOR TO THE 125-TON STEAM HAMMER, AT THE BETHLEHEM STEEL WORKS.

The partly dismantled hammer may be seen in the background, waiting the time when the demand for the space it occupies will lead to its complete dismemberment, and the melting furnace will convert its component parts into some other and more modern appliances.

growth of other processes springing from it, have come about a higher state of development and a greater advance in civilization than were caused by all previous inventions of man put together.



15,000-HORSE-POWER ENGINE AND PUMPS SERVING THE 14,000-TON HYDRAULIC FORGING PRESS, BETHLEHEM STEEL WORKS.

The majestic proportions of the press are suggested by the size of this individual power plant—as great as that of a large ocean liner.

But the wonderful impetus to industrial enterprise due to this discovery would not have obtained its strength had it not been for the influence of the technical institutions of learning, which opportunely at this time began to come into existence. For, as the arts could not be successful until the abstract sciences became exact, so also the latter were of no avail until they were made use of and incorporated in the industrial arts. As these institutions became operative, correct methods of reasoning, based on scientific knowledge of the principles of causation and sequence, were applied. The natural inclination of similarly educated minds to come together for interchange of thought brought about the technical society, where the effects of the application of scientific methods upon the forces of nature were discussed. Finally, when these discussions were widely disseminated by means of the latest and broadest educator, the technical press, then at last dormant minds awoke, latent thoughts were expressed in action, and misdirected energies were correctly applied.

In these early days industrial undertakings were not of great magnitude and methods of organization and management were necessarily crude, but concentration of attack by correct methods brought about unprecedented development in all lines of industry; opportunities for mental and bodily activity were presented on every side and enterprises grew in dimensions and increased in number. Strenuous effort to increase and improve product and to reduce cost in the severe competition that arose brought about rapid and great improvements in mechanical appliances. In some industries so great were the inducements offered to inventive genius for suggestions leading to economy and efficiency that improved machines were scarcely installed before others vastly superior were in the market to supplant them.

In fact, an instance is on record of an enterprising manufacturer, who, desiring to be foremost in his industry, had equipped his shops with what was considered the best machinery, but found himself in a few months behind his laggard competitors who had, by waiting, become possessed of a superior type of mechanism.

A case of this kind calls for but one method of handling, if the policy of keeping in advance is to be preserved; viz., to replace the recently purchased machines, all of which may be in perfectly good condition, by the newer equipment, or by that having a still higher efficiency, if such is obtainable. What then is to become of the discarded machines? The only market for them would seem to be among one's competitors, and yet they, if progressive, ought not to want them. Hence, as they will, in all probability, never be used again, their only value is as junk, and their relegation to the scrap heap is inevitable. That comparatively new, and in many cases costly, machinery can be deprived of its value by no accident to itself, and before its normal term of service has expired, is a fact that is well known to many men, both inside and out of manufacturing pursuits. There are, however, an equal number of men similarly occupied to whom such a possibility is beyond comprehension, and into whose estimates of deterioration of plant it does not enter at all.

Changes such as this are expensive, not only in immediate outlay for purchase, but in the lack of co-operation on the part of those on whom dependence must be placed to make the purchase a practical success. The substitution of new machinery for old may be of two kinds, and the enthusiasm of the operatives who are directly interested in any particular case will be minus or plus accordingly. In one kind the new machinery will seriously reduce the number of operatives, or, by the simplicity of its automatic features, will render skilled attend-

ants unnecessary, thereby reducing wages. Here at once a condition is confronted which makes the problem complex. It would, indeed, be an unusual type of humanity that would voluntarily and with any degree of enthusiasm aid in the erection of his own gallows. But there is another kind of substitution, where the machinery to be replaced may be merely larger or stronger, for the purpose of increasing the size of each piece of finished output; or the new may be such a modification of the old as would be necessitated by a change in design or shape of product. If fashion decrees a modification of type to suit its whim, the manufacturer must recognize and meet it at whatever cost. Such a change does not generally affect the number of operatives, or their wages, other than possibly to increase either or both at least temporarily. Beyond the incidental delays involved in adapting themselves to the manipulation of machinery that is unfamiliar to them, no particular discouragement on the part of the operatives may be anticipated.

It cannot, of course, be said that all the changes under discussion fall by a hard and fast rule into either one or other of the above divisions. Conditions vary, so that individual cases may fall partly in one and partly in the other category, and the situation is made more serious or ameliorated, depending upon whether complications of the first or second kind predominate. By far the largest number of sweeping changes in the machinery of manufacturing plants have been of the second kind. They may, in fact, be compared with the changes that are constantly taking place in the road-bed and rolling stock of all our railroads. Light rails are replaced by heavier ones; bridges which are perfectly sound give place to others of stronger construction. Cars and locomotives, although in good condition, are disposed of and others of heavier build and greater capacity replace them. A most notable instance of this type was the Niagara Suspension Bridge, which, erected in 1853-55, at an expense of about $400,000, was replaced by a stronger structure, of cantilever type, in 1897, at a cost of approximately $315,000.

Changes such as these take place in consequence of the increasing demands of industrial development, which, by its tendency towards concentration, calls for the transportation of larger and heavier machinery and for bulkier cargoes of coal and food supply. In times of great industrial growth, advance is most rapid in those lines which supply the demands of that development, and radical measures must often be taken in individual manufacturing establishments, in order that they may be able to keep up with the growing demand.

As we look back through the last third of the present century, glancing at those industries which have made most rapid strides in progress, many conspicuous instances of this practice of scrapping expensive machinery are noticeable. Of all the many enterprises, those which have been associated with and closely related to the iron and steel industry have had the most phenomenal growth. From among these we will first draw a few examples.

Up to 1857 iron-rolling mills were crude affairs, with trains of two-high rolls and reversing engines. In that year the Cambria Iron Company, of Johnstown, Pa., intending to overhaul their rail-mill, called upon their superintendent, Mr. John Fritz, for a design. Mr. Fritz submitted one for a three-high roll-train, which, after considerable persuasion on his part, was accepted. The mill was built and run, and turned out rails successfully, but only after bitter opposition on the part of the operatives. The men went on strike and burned down the mill, but it was rebuilt, and by the time it was in operation the three-high train of rolls was an assured success. The foremost mills throughout the country at once scrapped their old two-high trains and substituted for them the later and more efficient machinery. The original two-high mill at the Pencoyd Iron Works, Pencoyd, Pa., after running eighteen years, was at this time replaced by a larger three-high mill, with a new engine and entire equipment, complete. This mill, after running twelve years, was also scrapped, on account of the advent of the Bessemer process and the change of product from iron to steel.

The old "crocodile squeezer," used to expel the slag from puddled iron balls, was in use in all iron mills up to 1840, when the rotary or so-called "coffee mill" squeezer was invented by Henry Burden, introduced by him at his iron works at Troy, N. Y., and afterwards put on the market. The adoption of this mechanism was also at first attended by much opposition on the part of the employees, owing to its automatic features and the tendency to dispense with skilled labor, but this very efficiency made its adoption insistent, so that, notwithstanding the fierce appellation of its predecessor, it replaced it in a few years and was the cause of its utter extinction by scrapping.

Generally speaking, this practice has been adhered to as a business policy in the representative rolling mills of the United States, such as the Carnegie Steel Company, the Illinois Steel Company, the Pencoyd Iron Works, etc. In the plants of these concerns whole mills have suffered scrapping, in a manner similar to the fate of the two-high roll train, whenever a number of improvements were offered,

which, if applied to the old mill, would have practically amounted to its rebuilding.

Fifteen years ago the last mentioned company built a 20-inch three-high structural mill driven by a 32-inch by 48-inch vertical engine. This mill was considered by the engineering world a model of its kind. After running ten years, however, so many improved mills had been built at other plants that it was considered out of date. After attempting to introduce new tables and manipulators for handling material, and to otherwise modernize it, the whole mill, engine and all, went into the scrap heap, and in its place was erected an entirely new mill for turning out exactly the same product, viz., structural material, but, of course, to much greater advantage.

Improvements in furnace design have invariably led to the scrapping of the old, with a constant tendency towards increase in the size of the new. As these metallurgical appliances are constructed entirely of brick, it is easier and cheaper to tear them down and cart them to the dump than to attempt to modify them. A noted example of this was given by the Midvale Steel Company, of Nicetown, Pa., which, in 1874, changed its method of melting steel from the crucible to the Siemens-Martin process as being better suited for its product of tires, axles, etc. A fine row of crucible furnaces, etc., was destroyed and on its site an open-hearth plant of latest type erected.

The Bethlehem Iron Company, South Bethlehem, Pa., in 1890 erected the largest steam-hammer ever built, having a capacity of 125 tons falling weight. This was operated successfully for three years in the manufacture of armor-plate, but when, in 1893, a new type of this product was invented by H. A. Harvey, it was found that the hydraulic press was better adapted to its manufacture, and this enormous tool, which, with all its accessories, cost in round figures a quarter of a million dollars, was immediately set aside, to be replaced at a similar cost by a hydraulic press, which to-day still remains the largest in the world. This is probably the most notable instance on record, on account of the great expense involved, of the substitution of a more efficient tool for another, the normal life of which had only just begun. In this instance the hammer was not scrapped, in the hope that some day its use might be revived, but has stood in a partly dismantled state for seven years, the probabilities now being that, as the hydraulic press has entirely superseded it, when the natural expansion of the works demands the ground it occupies it will find its way to the melting furnace.

In 1897, Krupp having perfected a new type of armor-plate, part of

the furnace plant previously used in the manufacture of Harveyized plate at South Bethlehem was torn down, and furnaces of a new design, with a gas-generating plant, were erected in their stead, resulting in a vastly more efficient product. Now a Krupp plate 6 inches in thickness will resist impact where previously a 10½-inch plate was required.

Also, in 1899, while experimenting to establish a standard grade of tool steel for use in the machine shops, two engineers employed by the company, Messrs. F. W. Taylor and Maunsel White, discovered that a special treatment applied to a steel of peculiar composition would impart to it a property of resisting fusion at very high temperature. Application of the use of this steel has been made to cutting tools, where its power to resist the heat due to the friction of cutting enables it to work at from twice to three times the speed of the best tool steel in the market. The adoption of this steel throughout the shops at once necessitated great changes in shop methods. Countershafts running at 90 revolutions were speeded up to 250 revolutions, and provision was made for enabling individual machines to be still further speeded up. This increase in speed has raised the number of pounds of metal cut per tool per hour from 30 to more than 150. Naturally, an increase of machine output of 500 per cent. was not accomplished without considerable expense, from modifications made necessary by the changed conditions of working. More than 50 tons of old cutting tools were disposed of in the market for what they would bring. Subsequently this new tool steel and treatment process were put on the market and shop rights sold to representative concerns in America, and European rights are being disposed of, the English rights having already been obtained by Vickers Sons & Maxim. There is no doubt but that the speeds obtained by this treated tool steel will eventually become standard. Their adoption will be slow, as all healthful growths should be, but when accomplished there will have been brought about a complete revolution in machine design and in machine-shop practice and a scrapping of hundreds of tons of less-efficient tool steel.

The great combinations of capital which have taken place during the past two years have united into one harmonious entity the efforts of separate and competing manufacturing establishments.

In the course of reorganization many of these plants have been found to be not as modern in equipment as others, or are less advantageously located. In the focalization of effort at central points, the tendency towards which practice we are constantly encountering, many

of these plants have been dismantled and their contents sold on the spot for junk, not being deemed worth the cost of transportation; and yet, until the fever for combination swept across the land, the firms which operated these same plants were satisfied with their condition and looked forward to many years of prosperity in the use of the equipment then employed.

The development of electricity has been a potent factor in bringing about in all industries the substitution of machines operated by that force which were previously run by air, steam, or water. The ability thus afforded to concentrate the generating power plant into one central station, from which power for all purposes could be developed and transmitted to great distances by mere wires, enabled great economy to be attained by substituting traveling cranes, lifts, elevators, and various other appliances individually driven by electricity for those otherwise controlled. In many of these cases, however, the machinery displaced, except when it was of special design, has been disposed of to others for what it would bring, instead of being annihilated.

On all sides may now be seen examples of the change of motive power on street railways, from the horse and cable propulsion to electricity. In 1890 the central station of the Boston Street Railway was designed and built, the company intending to equip it with electric generators of larger size than any previously contemplated. After carefully considering the requirements of the plant it was determined to drive these generators by belts, previous experience in this direction fully warranting the following of precedent. Considerable delay occurred in the furnishing of these generators, and smaller ones were temporarily loaned to take their place. Meanwhile, in one of the other stations of the road, some direct-connected generators were installed and an opportunity was thus afforded to compare their efficiency with those that were belt-connected. The difference was so plainly in favor of the direct-connected type that, as there had in the meanwhile developed a need for additional power, steps were immediately taken to change the central station to a direct-connected plant. The belted generators were taken out and the engines equipped with new shafts, pillow-blocks, and flywheels, and new direct-coupled generators. By this means more floor space was obtained and the capacity of the station was about doubled, with very little additional cost for operation. Here it must be noted, however, that not all of the machinery was scrapped; only the shafts, pillow blocks, and flywheels suffered that fate, the generators being sold for about one-fourth the original cost.

In this case the alternative would have been the purchase of a new

site, and the erection of a new building, with complete equipment. By making the change as outlined an undoubted saving was accomplished in total outlay, the returns from the sale of substituted machines and scrapped material aiding in materially reducing it.

We are at the present time viewing the struggle between the southern States and New England for the final home of the cotton mill. The proximity of the raw material and the unlimited supply of cheap child labor in the South at present favor that locality, and threaten the long-established and enormous mills of the East. In the growth of this industry competition has been most severe, and the introduction of labor-saving machinery has been accompanied by long and serious strikes. The experience of the largest cotton mill in the world, the Amoskeag Manufacturing Company, at Manchester, N. H., may in its struggle for supremacy be considered representative. Here recently have been consigned to the shears several hundred "top flat" cards that were doing just as good work as the "revolving flat" cards which replaced them, but by the change more work at less cost could be obtained from the same floor space. Several hundred looms which were making good cloth have been broken up to make way for others that replace an empty filling bobbin with a full one without stopping, thus enabling a weaver to attend more looms. A thousand Scotch looms, whose normal life would have been 20 years, and which were imported at a cost of $100,000, were scrapped after 10 years' service to be replaced by others of American design which make practically the same goods at less cost.

So it has gone, and so it still goes, with those enterprises which are to survive in the struggle for existence. Concerns may be compared to human beings, the management being likened to the mind, the equipment to the body. They have their youth, their prime of life and their old age, and finally they die. According as the management is active and keeps itself informed, or settles comfortably down, relying for success on its reputation or the peculiar environment which brought it into existence, will depend its health and whether it will stand a giant of its race or die a weakling.

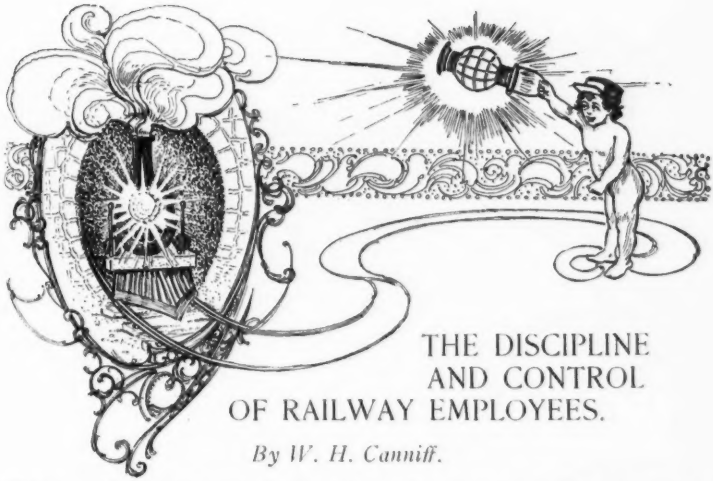
The more rapidly changes take place in industrial conditions the more readily must the policy of management be adapted to meet them. Never was competition more severe, and never have more concerns of old standing and tried reputation gone to the wall or been absorbed by younger ones than at the present time. And the reason is that their management has not kept itself informed and followed the methods of younger and more active enterprises. An intuition of expediency,

born of a broad experience, is a possession essential to successful management.

Harmony between the management and the operating force is essential, and the antagonism engendered by the feeling that the management looks upon its employees as a necessary evil must be obliterated. In the introduction of modern equipment and modern methods the lack of co-operation on the part of the operatives is the most serious source of trouble. It must be evident to the veriest tyro in the science of management that to keep abreast of the severe competition of the day the paternalistic methods of the first two-thirds of the century must give way to the individualism which dominates modern policy. It is only rational to suppose that new methods and appliances will be taken up more readily by those who are educated and encouraged to be efficient than by the survivors of a harsh and degrading despotism.

Huxley says, "There are two opposing methods at work in the government of the world—respectively the ethical and the cosmic." The practice of that which is ethically best involves a course of conduct which in all respects is opposed to that which leads to success in the cosmic struggle for existence. In place of thrusting aside or treading down all opposition, it requires that the individual shall not merely respect, but shall help his fellows. Its influence is therefore directed not so much to the survival of the fittest, but to the fitting of as many as possible to survive. By no other scheme of management can any enterprise hope to keep in the front than by that in which ethical principles have been strongly indoctrinated.

Experts in the science of shop management are doing great good to humanity by preaching practical religion, for they are teaching business men that "it pays" to introduce into their works methods and appliances which will uplift their fellow men. Technical schools of the first order have already admitted to their forums lecturers on this subject, but the institution that first includes in its curriculum courses in manufacturing and social engineering will send forth into a public field a host of workers who will garner a rich harvest. For the more enlightened the type of man employed, the better will be his work and the higher will be the standing of the firm that depends upon the result of his labor for its success. Among such men methods can be introduced which will stimulate them not only to exert their maximum of effort in the minimum of time, but to offer suggestions toward improvements in methods and appliances. Such methods will soon bring about a condition of affairs where the relegation of a comparatively new tool to the scrap heap, when another of greater efficiency has been devised, will be the most ordinary procedure.



THE DISCIPLINE AND CONTROL OF RAILWAY EMPLOYEES.

By W. H. Canniff.

IN considering the relations of the railway to its employees every thinking person will at once recognize the vast complications which the problem presents. Not only is it necessary to provide for prompt handling of merchandise under every conceivable condition, but such provisions must be made as will insure the safety and comfort of thousands of passengers who use the roads, as well as those of the men employed.

Again, the railway company is known to the communities through which its lines pass only in the persons of its accredited agents, and upon their tact and general bearing must largely depend the esteem in which the company is held, resulting in coöperation or antagonistic relations as the case may be. Not only does this apply to commercial relations, but also to such police regulations as look to the clearing of streets and similar requirements on a long line of railway. How to

Mr. Canniff's article on "The Relation of the Railway to its Employees," first written in 1895 and published in THE ENGINEERING MAGAZINE for March of that year, has ever since stood as a classic in the literature of railway-labour management, unapproached by anything else written on the topic. The six years intervening have brought its author great advance—largely increased responsibilities—ample scope to test to the uttermost the principles enunciated. And in response to the request that he restate his views for the far wider audience reached by this international issue of the Magazine, he writes: "I have most carefully gone over the article in detail, reaching only one conclusion, viz., I have nothing to add, no change to suggest. It represented my views then—it does now. I am more clearly convinced than ever before that the principles enunciated in this article, if applied to either large or small corporations, will bring good results." Mr. Canniff's review stands, therefore, as the formulation of a policy so surely founded on bottom principles that it has stood the trial of daily application, in every aspect of labour matters and general economic conditions, throughout the whole range of relations found in a great organisation, and has never failed nor needed readjustment.—THE EDITORS.

insure this desired result is one of the most perplexing problems which confront a manager.

It is manifest that good and sufficient discipline is a prime factor, of which, to my mind, absolute justice is the foundation principle; and on this basis can the obligation of a railroad company to its employees and to the public be best carried out. It is obvious that, whatever the rules and regulations, their execution depends upon a large number of men surrounded and largely influenced by varying conditions. This being true, it follows that, in the formation of all rules governing the operation of a railway, great care should be exercised to see that they are based on correct principles, neglecting no feature which experience has shown to be necessary in an intelligent execution of such rules, and taking into account the various phases which affect human nature as a whole, remembering that those who are to execute the rules are a part and parcel of the human family.

At this point, however, the work has just begun. While to the mind of an intelligent officer the rules or instructions are clear and explicit, he should bear in mind that their execution depends largely upon an equally intelligent comprehending and understanding by those who are to carry them into effect.

When it is realized that an author usually devotes chapters to definition in order to convey exact ideas, it will be admitted that to give correct expression to ideas much thought and study are required, and that those who are to receive the idea must understand the language used for its conveyance. Hence the great necessity for intelligent direction is apparent.

Men who do not have a fairly intelligent idea of what may be termed the general fitness of things are very low down in the scale. Much more plainly than their employers imagine do they see the relation of the order, or instructions, to the work to be done. The nature of their work makes them keen observers in most instances, quick to recognize in the instructions even the slightest defects, or mistakes, or the want of application to the work in hand, which cannot fail to weaken their respect for those who issue them; and, while the mistake may be easily corrected, the effect upon the men remains.

They have the same hopes and fears, aspirations and desires, as other men, and are surely deserving of every consideration when the importance of their work is remembered. That the employee will do more efficient work if his interest and coöperation are secured cannot be controverted, for the evidence is at hand in every walk of life. When fairly balanced, the interests of the railway company are identi-

cal with those of the employee, for with good discipline and highly efficient labor the comfort and safety of the public is conserved, the investment is made profitable, and good wages can be maintained. How can this desideratum be achieved?

First: by most painstaking care in the preparation and promulgation of rules and instructions.

Second: by clearly conveying to the employee what is desired, it being his right to know what is expected of him under all circumstances.

Third: by having him understand that the rules are such that, if intelligently executed, they will insure his own well-being, as well as that of the company, and that compliance with them will result in recognition, either in the way of commendation or promotion.

Fourth: by strict attention to matters of discipline, never permitting employees to be suspended or dismissed except for good and sufficient cause—this to be shown by clearest proof of violation of rules that were fully understood, and such violation to be invariably disciplined, without waiting for the evil consequences which such rules were intended to avoid.

Fifth: by a consistent course of action which will impress upon the employee the fact that it is the earnest purpose of the company to render him exact justice in every instance.

Men entrusted with the care and responsibility of handling a large body of employees widely scattered over an extended territory must have exceptional talent in order to secure the best results. They must fully understand how vast the interests are which are committed to their care, and upon their fidelity and wise direction the welfare of many employees and their families depends.

The first proposition—that great care should be exercised in the preparation of rules and instructions—is certainly of vast importance, owing to the fact that these are, of necessity, the foundation upon which the whole structure is to rest. They must be such as practice and experience have approved. For illustration, in the preparation and adoption of a schedule, affecting, as it does, during its existence, the movement of every train or engine, there is most valuable information to be gained by consulting those employees whose duties bring them in daily contact with the service performed. Thus not only does the management get the benefit of the employee's experience, but the employee is encouraged to study more closely the problems which arise in the service, with a full knowledge that his ideas will receive the consideration they deserve.

Again, much stress must be laid upon the second proposition. Not only must the foundation of the rules or instructions be clear and conclusive to their author, but the rules must be so worded as to convey to the employee the desired meaning; and to this end the employee should be encouraged to make it known promptly if there is anything in his instructions which he does not fully and clearly understand, thus giving him incentive to comprehend better, and confidence to ask for necessary explanation.

The third proposition calls for such wording of the rules as will adequately explain their purpose. Where for various reasons they cannot be so worded, a duty may devolve upon the management to explain the reasons for issuing them. It will be said that this is impracticable, but I do not deem it so. If a well-disciplined and highly efficient corps of men is desired, additional duties will be forced upon the management, as well as upon the men. To give the men a logical understanding of the rules is not as difficult as it may appear, and the advantage to be gained in the moral effect upon the minds of those who are to execute more than compensates, in my opinion, for the additional care and labor. It obliges the maker of the rule to exercise greater care in its preparation, in order to defend it when questions arise, and leaves the employee no possible excuse for failing to carry out its provisions.

In considering the fourth proposition, we come to what may properly be termed the most vital point of all.

To write an order, or issue instructions, is a simple matter. To secure the desired result is quite another matter; and, even when care has been exercised, and the instructions are based on good and sufficient reasons, a proper execution is difficult to attain.

The science of good government has occupied the minds of able men for centuries, and various methods are proposed in governmental affairs. Legislation in many instances is followed by failure through neglect of the underlying principle that governs all human action—*viz.*, that man must be held to strict accountability for his actions, in whatever he is required to do. An infraction of nature's law brings inevitably a punishment, mild or severe. It seems, therefore, fair and reasonable that the employee, after assuming his obligations, should be held to a strict accountability, and that a reprimand, suspension, or dismissal should follow an infraction of his instructions. Before inflicting the penalty, however, ample opportunity should be given him to present fully his side of the case, and action deferred until his fault or blamelessness has been clearly shown by good evidence.

After many years' experience, I have yet to see men fail to recognize and acquiesce in decisions arrived at by this method; and still more positive confirmation of its value is found in the remark, made to me by a distinguished railroad manager, that, after thirty years' service in charge of large numbers of men, and during that time having reprimanded, suspended, and dismissed a great many, he could not recall a single instance where such men did not continue to be his friends. What stronger proof could be offered that his relations with the men were governed by justice and fair dealing?

To impress the employee with the fact that justice will be done, as contemplated in proposition five, it is necessary to treat all infractions logically, and to attend closely to those small details which affect his relation to the company. This, for the busy manager, is difficult; and it will be said that, with all this care and attention on the part of the manager, or superintendent, there will be many employees on whom it will have no effect. This is true; but this very method of investigating acts and judging conduct becomes at once the active agent for ridding the service of such men, while a marked raising of character will be observed in those who are amenable to its influence, so that the efficiency of the service will be improved at both ends, and in a most striking manner, indicating how essential is constant vigilance on the part of the manager to the development of the efficiency which it is aimed to secure.

We must remember the great magnitude of the railway interests, and that nearly the whole of their wonderful development has taken place during the past fifty years. The railway corporation, even more than any other, is of necessity entirely removed from contact with the men, and the managing officer should aim to serve as a link connecting the interests of the men with those of the corporation. Personal contact, even by the manager, is necessarily infrequent and spasmodic, but all the advantages of personal contact can be secured by the just and impartial review of questions which arise between the men and subordinate officers. While the decisions thus rendered can serve as precedents for the determination of similar questions as they again arise, in this manner also the caprice of judgment shown in passing on similar offences on separate portions of the line can be corrected, and all divisions be brought to act in unison, this uniformity of action forming an essential part of that justice which is deemed essential to good discipline.

The public are daily becoming more exacting, and of necessity the railways must meet the changed conditions. The older employees

must of necessity adapt themselves to the new order of things, which means, in many instances, a change in the habits and practices of years. This can best be accomplished by appealing to their reason, as indicated above, and gradually bringing them to act from proper motives, through conviction that good results will be attained thereby.

As one illustration of the effect of appealing to men's understanding, I will cite the following:

It became necessary to change the location of a division terminal, in consequence of which the runs of one end were made much shorter than those of the other. Soon after, the men making the shorter runs demanded the same remuneration that they had received for the mileage formerly made, although the men on longer runs, under the new arrangement, did this work, and received the pay for it. It was claimed that the division time-card had not been changed, and the men insisted that the time-card distance should rule. Answer was made that their request would be granted, and they must decide for themselves whether the time-card distance or the actual distance run should govern. The time-card distance was at first decided upon; but, when it was shown that, if the time-card distance governed in the one case, it must also govern in the other—that, if the men of one division received pay for thirty miles which they did not run, the men on the other division, under the same rule, would run thirty miles without receiving any pay for the same—the men reconsidered their request, their acquiescence to the existing arrangement being given in such a manner as to leave no doubt of their conviction of its justice.

To show the force of emulation, I may state that, while in charge of a track division comprising fifteen sections, each under a foreman, I have repeatedly instructed seven of the foremen to perform work at the ends of their sections tending to improve materially the condition and appearance. In no single instance did I fail to find the eight alternate foremen doing the same work not later than the second day, although no instructions whatever had been given them, the contrast and improved appearance of the adjoining section impelling them to similar action. In this manner the men are mentally and morally strengthened, while the quality of their service is much improved.

The apprentice who enters the railway machine-shop with proper qualifications for success will in good time become a master workman, capable of directing the building of a modern locomotive. Such men, taken as a class, will be men of fixed ideas and purpose. Their work has required exactness in every detail, performed under the watchful care and within reach of the helping hand of a resident official.

To place such a man in charge of the machine he has built, which, in its frequent trips, by night and day, surrounds him constantly with uncertainties, calling for exercise of individual judgment and the faithful discharge of duty in the absence of all personal supervision, is to change absolutely his environment, and consequently his ideas and inclinations; and, although the same person, yet he is in an entirely different class, requiring different treatment, all of which should and will be considered by the intelligent officer. In other words, the latter will recognize the plain distinction between employees whose duties tend to fixed results, and those whose duties are full of uncertainties, as in train service.

Absolute frankness upon the part of those in authority, when dealing with the men, forms an essential part of the relations which the railway company should bear to its employees. If requests are made which cannot consistently be granted, it should be answered that such is the case, it being far better that the employee should be disappointed at the time rather than suffered to entertain hopes not to be realized in the future.

In many instances promises of promotion are made with an undoubted intention to fulfil them; and yet, as every officer knows, circumstances over which he has no control arise to prevent the fulfilment. Not only are such failures disappointing to the parties directly interested, but they involve a lowering of confidence in the minds of the employees in general, which must tend to weaken discipline, however slightly. As no explanation can change these feelings, avoidance of promises is the wiser course.

In acceptance of new men for the various branches of the service, it is of advantage to the company, and positively due to the men already employed, that the existing standard of efficiency should be maintained. To this end suitable references should be required, with the understanding that the applicants will not be employed until such references have been looked into, and assurances received that the applicant is worthy in character and gives evidence of capacity, as only by such discriminative methods can justice be done to the employees whose capacity has been proved.

In the relations of the railway to the employee, it is the part of wisdom for the railway officer, when positions become vacant, to promote, whenever possible, some one of the employees already in service. It is true that in the strict sense the obligation of the company to the employee ceases when the stipulated sum has been paid him for the service rendered; it is equally true that with the performance of a fair

month's work the employee has discharged his full duty; but, as we seek to increase the efficiency of the service, evidences of unusual loyalty and energetic performance of duty should be met with due recognition by promotion to such positions as call for the exercise of the qualities displayed.

Since the improvement of the men is an advantage to the service, there is much to be gained by railway companies in taking an interest, and aiding pecuniarily, in the provision of suitable quarters at principal points where employees can spend their leisure hours surrounded by good influences. In this way the Young Men's Christian Associations have rendered valuable service, and it is a pleasure to note the rapidly-increasing interest shown in this direction by many railway officials, and the appreciation of such efforts by the employees, as evidenced by increasing attendance and interest, thus conclusively proving the good results upon men when they become impressed with the evidence of concern for their personal welfare.

Thus it is that we find large numbers of men engaged in an occupation the nature of which requires keen perception and close adherence to fixed rules. Any failure on their part may result in loss of property or danger to human life—a most exacting service; yet, considering the interests involved in the movement of freight and passenger trains, how faithfully their service is performed! But success in this, as in any other form of government, can only come with close study and constant watchfulness.

The relations of the railway to the employee being impersonal, the manager must in his own person fill the void. The employee is, in a great measure, what the manager's conduct makes him. If the manager desires an interest in the work aroused, he must show an interest in the men. When strict and intelligent obedience to the rules is demanded, the manager must not shrink from a strict and intelligible construction of them. If he wants the employees fearlessly to discharge their duties, he must as firmly uphold them where no blame is shown.

When more than usual zeal is manifested, promotion is a wise means of proving appreciation. Wisdom in judgment will command respect, honesty of purpose will win confidence; and, when these reciprocal obligations are recognized and performed, the relations of each to each will be better understood, a more friendly feeling will arise, fewer strikes will prevail, and, in the determination of the honest differences which may arise, the convictions of reason will prove a more potent factor than coercive force.

STRENGTH AND WEAKNESS OF THE COMBINATION OR TRUST IDEA.

A SYMPOSIUM OF EXPERT OPINIONS.

NO special publication devoted to problems of organization and management, as this is, would be complete without some practical discussion of the principle of consolidated industries, or Trusts, of which we have seen such phenomenal development within the past three years. Unfortunately, however, the subject has been fairly written to death. But the problem will not down, and as yet it is still far from the point of final settlement. Moreover, these great industrial combinations are now in existence, and in England at least the movement to form new ones is still in active progress. It is of the first importance, therefore, that the practical men who succeed the financiers in the actual management of these vast enterprises shall clearly understand the underlying principles of their organization.

As the most effective means of making these principles clear, therefore, it has seemed to us appropriate to quote the best that has already been written by acknowledged authorities *pro* and *con*, rather than to attempt to write anything new. Fortunately, too, the past half year has given us three very notable expressions of opinion from authorities of unquestioned standing and influence in the United States, where the trust movement has been carried to its highest development; and these, added to the memorable declarations of Lord Chief Justice Russell during the last two years of his life, make a symposium of expert opinion which should leave no man in doubt as to the essential principles and conditions which must govern industrial enterprise in the light of this modern development.

MR. ROCKEFELLER AND STANDARD OIL.

The fruitful parent of all the trusts that have been formed in the United States is the Standard Oil Company. That is not only the oldest, but it is the strongest aggregation of capital and business capacity ever yet drawn together in any branch of productive enterprise outside

railway operations. Matchless in the perfection of its organization, astonishing in its economies of production, and more astonishing in the low prices at which its products are marketed, it is the model from which every argument in support of the trust idea has been drawn. And so often and so furiously has it been attacked by press and pulpit, state legislatures, legal functionaries, and reformers of every kind and degree, that the American people have come to look upon it as a thing which must endure because of the essential soundness of the principles upon which it is builded. But the secrets of its strength are perfectly obvious to men who are trained in economic thought; and fortunately we have lately had from Mr. John D. Rockefeller, its creator and organizer, an authoritative statement clearly indicating the character of the Standard Company's business, and frankly stating its policy, methods and aims. This is not only the very ablest argument ever yet published in advocacy of the combination principle, but its perfect openness of statement, in contrast with the prevailing policy of secrecy in company affairs, shows plainly that Mr. Rockefeller and his associates now clearly recognize that publicity is the surest safeguard of legitimate manufacturing enterprise.

Summoned before the Congressional Commission, sitting in Washington to investigate the trust problem, Mr. Rockefeller was presented with a series of questions, to which he replied in writing. Beginning his statement with a direct reply to the question, What was it that induced the original combination of firms in the oil business, Mr. Rockefeller said:

"The desire to unite our skill and capital in order to carry on a business of some magnitude and importance in place of the small business that each separately had theretofore carried on.

"As the business grew and markets were obtained at home and abroad, more persons and capital were added to the business and new corporate agencies were obtained or organized, the object being always the same—to extend our business by furnishing the best and cheapest product.

"I ascribe the success of the Standard to its consistent policy to make the volume of its business large through the merits and cheapness of its products. It has spared no expense in finding, securing and utilizing the best and cheapest methods of manufacture. It has sought for the best superintendents and workmen, and paid the best wages. It has not hesitated to sacrifice old machinery and old plants for new and better ones. It has placed its manufactories at the points where they could supply markets at the least expense. It has not only sought markets for its principal products, but for all possible by-products, sparing no expense in introducing them to the public. It has not hesitated to invest millions of dollars in methods for cheapening the gathering and distribution of oils, by pipe lines, special cars, tank steamers and tank wagons. It has erected tank stations at every important railroad station to cheapen the

storage and delivery of its products. It has spared no expense in forcing its products into the markets of the world, among people civilized and uncivilized. It has had faith in American oil, and has brought together millions of money for the purpose of making it what it is, and holding its markets against the competition of Russia and all the many countries which are producers of oil and competitors against American oil.

"Much that one man cannot do alone two can do together, and once admit the fact that co-operation, or, what is the same thing, combination, is necessary on a small scale, the limit depends solely upon the necessities of business. Two persons in partnership may be a sufficiently large combination for a small business, but if the business grows or can be made to grow, more persons and more capital must be taken in. The business may grow so large that a partnership ceases to be a proper instrumentality for its purposes, and then a corporation becomes a necessity. In most countries, as in England, this form of industrial combination is sufficient for a business co-extensive with the parent country, but it is not so in this country. Our Federal form of government, making every corporation created by a State foreign to every other State, renders it necessary for persons doing business through corporate agency to organize corporations in some or many of the different States in which their business is located. Instead of doing business through the agency of one corporation, they must do business through the agencies of several corporations. If the business is extended to foreign countries—and Americans are not to-day satisfied with home markets alone—it will be found helpful and possibly necessary to organize corporations in such countries, for Europeans are prejudiced against foreign corporations, as are the people of many of our States. These different corporations thus become co-operating agencies in the same business, and are held together by common ownership of their stocks.

"It is too late to argue about advantages of industrial combinations. They are a necessity. And if Americans are to have the privilege of extending their business in all the States of the Union and into foreign countries as well, they are a necessity on a large scale and require the agency of more than one corporation. Their chief advantages are:

"1. Command of necessary capital.

"2. Extension of limits of business.

"3. Increase of number of persons interested in the business.

"4. Economy in business.

"5. Improvements and economies which are derived from knowledge of many interested persons of wide experience.

"6. Power to give the public improved products at less prices and still make profit for stockholders.

"7. Permanent work and good wages for laborers.

"I speak from my experience in the business, with which I have been intimately connected for about forty years.

"We soon discovered as the business grew that the primary method of transporting oil in barrels could not last. The package often cost more than the contents, and the forests of the country were not sufficient to supply the material for an extended length of time. Hence we devoted attention to other methods of transportation, adopted the pipe line system and found capital for pipe line construction equal to the necessities of the business. To operate pipe lines re-

quired franchises from States in which they were located, and consequently corporations in those States, just as railroads running through different States are forced to operate under separate charters. To perfect the pipe line system of transportation required in the neighborhood of $50,000,000 of capital. This could not be obtained or maintained without industrial combination.

"The entire oil business is dependent upon this pipe line system. Without it every well would be shut down, every foreign market would be closed to us. The pipe line system required other improvements, such as tank cars upon railways, and finally the tank steamer. Capital had to be furnished for them, and corporations created to own and operate them. Every step taken was necessary in the business if it was to be properly developed.

"The dangers are that the power conferred by combinations may be abused, that combinations may be formed for speculation in stocks rather than for conducting business, and that for this purpose prices may be temporarily raised instead of being lowered.

"These abuses are possible to a greater or less extent in all combinations, large or small, but this fact is no more of an argument against combinations than the fact that steam may explode is an argument against steam. Steam is necessary, and can be made comparatively safe. Combination is necessary, and its abuses can be minimized; otherwise our legislators must acknowledge their incapacity to deal with the most important instrument of industry.

"Hitherto most legislative attempts have been an effort not to control, but to destroy, hence their futility."

In order to estimate correctly the force and application of this statement from Mr. Rockefeller's pen, it is very necessary to bear in mind that he is refering directly to a great manufacturing enterprise founded primarily upon a natural monopoly. The supply of crude petroleum is limited rigidly by the flow from known oil fields. The problem with which Mr. Rockefeller and his associates have to deal, therefore, is to get control in each new oil field as it develops. Having in the course of years secured control of existing sources of supply, it is now a simple matter, with their enormous capital, their many miles of pipe lines, their great storage facilities, their thousands of tank cars, and their fleet of tank steamers—with these advantages, it becomes an easy matter speedily to gain control in each new oil field as it develops. These are the features of the Standard Oil Company's business which broadly distinguish it from every other branch of manufacturing and commercial industry; and it is here that the principle of combination and co-operation between closely allied companies has been legitimately and most wisely employed, with unexampled reward for all those who have participated in Mr. Rockefeller's enterprises.

MR. CARNEGIE AND COMPETITION.

And as Mr. Rockefeller's strong logic and matchless achievements convince us that combined ownership and centralized control must in

time supplant all other systems in the conduct of enterprises which may be classed as natural monopolies, so we have Mr. Andrew Carnegie, an equally distinguished authority, stoutly maintaining that in the field of manufacturing industry and commerce, competition is still the order of the day. Mr. Carnegie, no less than Mr. Rockefeller, is a consistent advocate of centralized control, production upon the largest possible scale, and the quick employment of every system and device that can lower the costs of production and enlarge his markets by meeting all possible competition. But he has refused to consider every proposal looking to the consolidation of his business with other interests in the iron and steel trades; and in May last he contributed a paper to *The Century* magazine, under the title "Some Popular Delusions About Trusts," from which we make the following characteristic extracts.

"The people are aroused against trusts because they are said to aim at securing monopolies in the manufacture and distribution of their products; but the whole question is, Have they or can they succeed in monopolizing products? Let us consider.

"There are only two conditions other than patents which render it possible to maintain a monopoly. These are when the parties absolutely control the raw material out of which the article is produced, or control territory into which rivals can enter only with extreme difficulty. Such is virtually the case with the Standard Oil Company, and as long as it can maintain a monopoly of raw materials it goes without saying that it can maintain a monopoly in the product. This is a fact that the public must recognize, but what legislation can do to prevent it is difficult to say. * * * Its second source of strength lies in the fact that through its extensive operations it has been enabled to reduce the price of its product to the consumer. It is a unique organization, for there is nothing like it in the world, and therefore it is not to be classed with the ordinary trusts.

"The genesis of trusts is as follows: Manufacturers of most staple articles (especially of iron and steel) are subject to long periods of serious depression, succeeded by short intervals of high profits. Because during depression no increase is made in capacity, and the world's population and wants are constantly growing, one morning it is discovered that demand has overtaken and outrun supply. But the production of increased supply is no easy matter. It usually means beginning at the beginning, obtaining the raw materials from mine or soil, passing these through various processes for which the necessary machinery and facilities are wanting, and it is a year or eighteen months, or even two years, before the supply of most articles can be materially increased. Demand becomes imperious and unsatisfied, and prices bound upward. Many new men are induced to build new works. The extensions of the old works supply all demands, and even a shade beyond; then comes the collapse. It is during one of these long periods of depression, when many of the manufacturers are on the verge of bankruptcy, that there arises in the heart a hope, soon crystallized

into a belief, that a new way has been found to avoid the natural consequences of the unchanging economic laws. It is soon felt that savage competition should cease between those enduring a common affliction, who should be brother manufacturers, and that the lion and the lamb should lie down together. They forget, in the hour of their misery, that the moralist has expressed the fear lest the one may be found inside the other. First, all kinds of understandings and fair promises are made—alas! only to be broken; and, finally, the promoter makes his appearance, and our unfortunate manufacturers fall an easy prey. Enormous sums are offered for antiquated plants which may not have been able to do more than pay their way for years. These are tied together, and the new industrial makes its appearance as a trust, under the delusion that if a dozen or twenty invalids be tied together vitality will be infused thereby into the mass. This is not true of all that are classed as trusts; there are exceptions. I speak only generally.

"Should these combinations be made upon the eve of a period of activity, as was the case recently, then there is a trimphant vindication of the new nostrum, the industrial world has found its panacea for all ills, and there is never to be ruinous competition again. The public is alarmed; it hears for a time of the advance of prices in the products of these gigantic concerns which temporarily control the market, and demands legislation against them. Generally speaking, as in the present instance, the advance in prices would have taken place even if no trusts existed, being caused by increased demand. The very name of trust stinks in our nostrils. We believe the public to be needlessly alarmed upon the subject, for the following reasons:

"Few trusts have a monopoly through patents or through the supply of raw material or of territory, and what happens is this: For a short time competition is hindered, but rarely, if ever, completely stifled. The profits of the trusts are high, and capital, ever watchful for an opportunity to make unusual gains, seeks its level by a law of its being, and needs only the opportunity to engage in this highly profitable manufacture. A relative of one of the principal officials or one of the chiefs of a department in the trust, knowing its great profits, gets some friend with capital to build new works in co-operation with him, and the result is that we soon see springing up over the country rival works, each of which has the great giant trust more or less at its mercy. A threat to reduce prices, and the trust, to which this may mean millions of dollars of loss, will sooner or later come to an agreement with the little David who threatens to attack the Goliath, and the rival concern is arranged with or purchased. This only whets the appetite of others who see the success of the first innovator, and other works soon spring up. No sooner has the trust purchased one threatened rival than two appear, and the end is disaster. The people may rest assured that neither in one article nor in another is it possible for any trust to exact exorbitant profits without thereby speedily undermining its own foundations. It is not long since trusts first made their appearance, and already many have disappeared. Many still existing are being assailed, the names of which will readily occur to our readers. Only a few survive to-day, and none have secured the coveted monopoly. Most of the metals and many of the staple articles have been formed into trusts, which, although yet living, are rapidly being attacked to their final destruction. The press used to tell every morning of the organization of some trust or other, and even to-day we will hear of proposed additions to the list

of these attempted gigantic monopolies, which enjoy a brief ephemeral existence. Upon most of them can already be written the appropriate epitaph:

> " 'If I was so soon to be done for,
> I wonder what I was begun for.'

"Every attempt to monopolize the manufacture of any staple article carries within its bosom the seeds of failure. Long before we could legislate with much effect against trusts there would be no necessity for legislation. The past proves this, and the future is to confirm it. There should be nothing but encouragement for these vast aggregations of capital for the manufacture of staple articles. As for the result being an increase of price to the consumer beyond a brief period, there need be no fear. On the contrary, the inevitable result of these aggregations is, finally and permanently, to give to the consumer cheaper articles than would have been otherwise possible to obtain; for capital is stimulated by the high profits of the trust, for a season, to embark against it. The result is very soon a capacity of production beyond the wants of the consumer, and as the new works erected are of the most improved pattern, and capable of producing cheaper than the old works, the vulnerable trusts are compelled to buy and capitalize at two or three times their cost. There is thus no danger ahead to the community from trusts, nor any cause for fear.

"The great natural laws, being the outgrowth of human nature and human needs, keep on their irresistible course. Competition in all departments of human activity is not to be suppressed. The individual manufacturer who is tempted into the unusually profitable business of the trust will take care of the monopoly question and prevent injury to the nation. The trust, so far as aggregation and enlargement go, is one day to be recognized as a grand step toward cheaper products for the people than could have been obtained by any other mode than the aggregation of capital and establishments. Already the ghosts of numerous departed trusts which aimed at monopolies have marched across the stage of human affairs, each pointing to its fatal wound, inflicted by that great corrective, competition. Like the ghosts of *Macbeth's* victims, the line promises to stretch longer and longer, and also like those phantoms of the brain, they 'come like shadows, so depart.'

> " 'The earth hath bubbles as the water hath,
> And these are of them.'

"The masses of the people, the toiling millions, are soon to find in this great law of aggregation of capital and of factories another of those beneficent agencies which in their operation tend to bring to the homes of the poor, in greater degree than ever, more and more of the luxuries of the rich, and into their lives more of sweetness and light. The only people who have reason to fear trusts are those who trust them."

If these two high authorities seem to differ radically as to the scope and application of the principle of combination, there is yet a striking similarity in the methods and careers of the two men. They are of one mind as to the wisdom of keeping the reins of control firmly within their own grasp; they have firm faith in the policy of production upon the largest possible scale; they know the power of low prices in enlarging markets and increasing consumption; they meet and overcome

competition by underselling it; and each man, with a singleness of purpose rarely seen, has devoted a lifetime to the development of the great enterprise which has yielded him vast and rapidly increasing wealth. The careers of both men give eloquent testimony to the homely truth that great business success comes most surely as the reward of intelligent, continuous, and concentrated effort, prolonged through many years, and highly specialized in one calling. Until lately that homely rule has held true of all business and all countries. But in these piping times of great prosperity, great business, great opportunities, and great fortunes quickly made, the old order seems, for the time-being at least, to have been superseded by a new era and a new *régime*. The practical man of business, the trained engineer, the manager, and the superintendent have all been superseded—in authority surely—by the promoter and the financier.

MR. DILL AND THE PROFESSIONAL PROMOTER.

We are quite prepared to sympathize with the view that the modern promoter and the underwriting financier have probably performed a useful function. But this Magazine is published and these pages are written in the interest of experts who devote their lives to the study and practice of the science of industrial management and constructive enterprise. We hold that, if the great combinations now formed and yet forming are to fulfill the representations of their sponsors and reward the faith of thousands who have invested in their shares, that can only come by quickly superseding the authority and influence of the promoter and financier by that of the practical man of proved capacity, with his staff of trained engineers, managers and superintendents. To that end, nothing can be more important than that the men to be charged with these responsibilities shall clearly understand the methods, the motives and the rewards of both the promoter and the financier. And happily we have at hand a very clear statement of this essentially important phase of the problem, from Mr. James B. Dill, the distinguished attorney of New York and New Jersey, who is credited with being the legal counsellor and having drawn the charters for a larger aggregate capitalization of great industrial enterprises than any other man now living. In the course of a notable public address last summer, Mr. Dill said:

"The labor of the professional promoter in this matter was not one of love. He was not actuated by methods of mere philanthropy; his purpose was to make for himself a profit out of the combination. This was generally done by making the stock issue of the company of sufficient size to enable the promoter

to get some of this stock. The manufacturer was inclined to be generous with that which apparently cost him nothing. * * * The promoter was not working upon the corporate problem to demonstrate an economic proposition from the standpoint of economics. He was seeking his reward, which was a block of stock. * * * His stock sought a market, and this brought the promoter into contact with the men who marketed the stock.

"We have now the origin of the financier.

"The financier saw that the promoter obtained his stock for his services, and that the stock was created for the purpose of paying for the services. * * * At this point another element arose which tended to increase the issue of watered stock.

"Instead of $500,000 propositions, propositions involving millions were sought for, in order that the promoter's and financier's reward might be in the millions rather than in the unit quantities, and perhaps with a view to make the ascertainment of the exact amount paid for promotion more difficult.

"There followed a tendency to surrender industrial principles, and to follow the promoter and the financier along promotion lines, rather than along truly manufacturing, mercantile, or industrial lines. What was the result? The answer is plain.

"Combinations began to be put together for speculative purposes, or, put it another way, the Wall Street end came prominently forward into the business of combinations. For the Wall Street purpose, it was necessary that the combinations should be of immense size and apparently involving whole trades. Neither the promoter nor the financier was able to dispose of it all, and therefore a market had to be created for it.

"This tended to create the so-called pirates among industrial combinations, sometimes designated as 'gambling specialties,' a class of corporations organized as industrials upon apparently economic principles, but really and truly for the purpose of Wall Street speculations, and speculations only.

"In such companies the director or trustee had largely disappeared so far as his duties as an impartial trustee for the stockholder, the wage earner, or indeed, the industry or business itself, was concerned. The tendency was that of a mad race to quick wealth; sometimes proceeding upon the principle that the end justified the means, forgetting that industrial enterprises could not be conducted on purely speculative or gambling methods.

"At this point, let it be clearly understood that by no means all combinations were improperly promoted, viciously financed, but be it confessed that some were.

"As to the future of those corporations which are overloaded with stock issues, whose valuations have been fictitious, whose aims have been speculative, we note that the organization of these companies, while ostensibly upon economic lines, has been really for the purpose of stock speculations. But the opportunity for this speculation is daily growing less and less; the investing public are becoming aware of securities of organizations which are over capitalized; the American public are buying with more care, are making more inquiries, are becoming more inquisitive as to what is behind the stock issue, and with the result that the market is lost to industrials which are in the nature of gambling speculations. The result will be that by a process more or less painful to the overcapitalized institutions, reorganization will take place, and such combinations will be put upon a truly industrial footing, or go to the wall.

"One thing certainly is now in the minds of the corporations of integrity, viz., to show plainly to the public what is back of the entire issue of stock, common and preferred. The public must have knowledge in order to buy and invest. The corporations must make knowledge public in order that they may not all go to destruction, and that the bad may stand out from and be distinguished as against the good.

"The so-called pirates in combinations have been the greatest injury to honest corporations of any of the elements existing to-day. For their own preservation corporations of integrity are urging a separation between the good and the bad. This is because the honest corporations know that they can stand that degree of publicity, while the inflated organization, the false industrial, will not dare make the same showing. The same need which called for the enactment of the national bank law (requiring official examination and periodical public statements) will no doubt eventually call for a national control of, and a national corporation law for, corporations which are truly national in their extent. This is but in a legal way carrying to its logical conclusion the principle which caused the organization of the combination, namely, 'centralization of control.' Applying this same principle of centralization of control to the law governing the corporations results in a national corporation law."

THE LATE LORD RUSSELL AND PUBLICITY.

Mr. Dill's expert and timely emphasis of the growing need, in defense of both stockholders and managers, for greater publicity in company affairs, is but an echo of the eloquent, forceful, and oft-repeated warnings upon the same subject from the late Lord Chief Justice Russell. Following the Hooley disclosures, it will be recalled that in his memorable address at Manchester, he said:

"That law has effected much good, but it has been, I am sorry to say, in many cases * * * prostituted by the greed of unscrupulous persons in the hurry to obtain great wealth without being willing to put forth for its acquirement honest toil and honest endeavour. * * * The problem, which is not yet solved by existing legislation, is to reconcile the useful operation of that act with such machinery as, if it cannot wholly prevent, will minimise evils of the nature and character to which I have referred.

"The first object ought to be to ensure, so far as practicable, that the public should be afforded all such information as would affect the reasonable judgment of a man in determining whether he would or would not invest in a particular concern; and the next object ought to be that all holding fiduciary or quasi-fiduciary positions should be bound to disclose fully and clearly any interest which they possess differing from the interests of the other shareholders—in other words, that the transactions should be open and above board, and all the parties dealing on equal terms.

"I have heard it said that it is impossible to make the law more stringent, because it will frighten away from the direction of public companies honourable and honest men. I do not say that that consideration is to be disregarded—far from it. But I do not believe that any honourable and honest man, who desires according to his conscience to discharge the trust that is imposed on him,

would suffer by any greater stringency of the law to give effect to the two objects to which I have referred. I said a few minutes ago that great pecuniary losses had followed these nefarious practices. The official receiver charged with winding up of public companies, who has rendered and is rendering the most valuable public service, has at my request furnished to me some figures on this head. They are startling. He gives me the figures for a period of seven years—from 1891 and up to and including 1897, and on the official information at his command, and taking the advice of those in a position to check the estimate (for in part it must necessarily be an estimate), he comes to the conclusion that in that period of seven years there has been lost to the community, and gone into unworthy pockets, no less a sum than £28,159,482, made up of losses of creditors dealing with companies £7,696,848, and of loss to the wretched contributors or shareholders £20,462,634. And when you recollect that these are the figures relating only to companies wound up compulsorily, and that they exclude cases of reduced capital, the losses in relation to companies whose shares were taken by the public at par, but whose present value only represents a very few shillings or pence in the pound of their par value, you will see that the loss to the public is enormous. But in addition to that is what I think is a weightier consideration—the effect of such transactions, if allowed to go on almost with impunity, on the public mind and confidence. These are pressing considerations, which show that these matters should be dealt with as of urgent importance."

Then again, a little over a year ago, at the inauguration of the Lord Mayor of London, he took occasion to say:

"The Legislature has recognised the need of measures aimed in this direction, for in several sessions of Parliament, Committees of the House of Lords have been endeavouring to solve in this relation the problem of how to prevent, or at least to narrow, the area of fraud, while at the same time not interfering with the useful efficiency and operation of the acts dealing with limited liability companies. The aim of any such legislation is clear and is simple. It is to enforce the rules of common honesty in the promotion of companies. When appeals are made to the public to subscribe to the capital of undertakings, it ought to be obligatory to disclose every fact known to the promoters and unknown to the public which might affect the mind of a reasonable person in determining whether he will or will not subscribe to the purpose of the undertaking. Everything ought to be above board; no concealment; no secret profits—the parties, public, and promoters alike ought to deal with equal information as regards the carrying on of such companies. The directors ought to be men of independence, not the creatures of promoters, paid by promoters, qualified by promoters, but men bringing reasonable skill and knowledge to the matters they undertake, and, even more important, independence of mind and perfect honesty to their task. My Lord Mayor, in saying this, I am not uttering any counsels of perfection. I am saying what the commonest dictates of honesty—common honesty—suggest. I hope that Parliament will feel itself competent at an early date to deal adequately and efficiently with this subject."

However men's interests, prejudices or convictions may cause them to differ upon these subjects, there are three conclusions to be

drawn from this array of expert opinion, in which all fair-minded men will probably be in agreement. They are these:

(1) In the operation of all natural monopolies, including railways, tramways, water works, gas works, and public utilities generally, the system of consolidated ownership and centralized control will gradually supersede all others—obviously because it admits of the most perfect organization, the highest economy in operation, and the best public service at the least price consistent with a fair return upon the capital invested.

(2) But in strictly manufacturing industry, competition is still the order of the day, as it must continue to be; and that firm, big or little, which can manufacture cheapest, sell lowest, and conduct its business with most skill and enterprise, is certain to survive. This means also and especially that it is the part of wisdom and foresight for such a firm to strengthen its position by acquiring a controlling interest in closely allied firms—as Lord Armstrong's firm has done in equipping itself to produce in its own yards a completed battle-ship; and as Mr. Carnegie has done in providing his firm with ample supplies of the best ore and coke. Every such move is a wise one when made to strengthen one's position, in recognition of the fact that "the survival of the fittest" is the obvious law of the manufacturing world.

(3) Finally, the interests of investors, and the kindred interests of industrial managers who require capital, plainly demand that these great industrial corporations, especially those listing their shares on the stock exchanges, shall be speedily required to give their stockholders and the investing public the benefit of that degree of publicity as to their affairs which has done so much to give stability and character to the investment shares of banking, insurance, and railway companies.

EDITORIAL COMMENT

IN technical journalism the special number must be the chronicle of some majestic occasion, or the herald of a great movement. If its theme is not of a high order, itself will lack not only dignity but also serviceableness and worth to its constituency; it will become a thing of sound and surface, wearisome to all. But when it is really infused with the power of some great work, seizing upon the essence and not the mere ornament; when it is inspired by a great conception, tracing its movement through the entire body of the industrial economy – the special number becomes the exponent of an era, important for all time.

The World's Fair Number of THE ENGINEERING MAGAZINE, the first great effort of the kind in engineering journalism, was the natural outgrowth of the greatest industrial exposition the world had seen up to that date. America then made her first striking appearance in the international congress of engineering, and the digest of results, presented in these pages in January, 1894, marked a new departure in engineering literature. That special number was pre-eminent through the magnitude of its subject and through its voiced recognition of the yet unfamiliar fact that commerce and manufacture were breaking through political boundaries, and that engineering practice must follow in making its range international.

* * *

Advance since that time in all lines—and especially in industrial expansion—has been so stupendous as to make one ready to accept the ratio quoted by Mr. Porter in his article in this issue—that the progress of each year equals that achieved in the preceding two years. The marvels of that day have become the commonplaces of this; the mysteries of 1894 are the axioms of 1900. Electricity alone, as Dr Bell points out, has experienced a development in the last decade of the century perhaps greater than steam had attained in the other nine, and the growth is particularly evident in the case of electricity only because this branch of applied science is comparatively young and the scale is more easily applied. Throughout the entire range of engineering activity the same process is apparent—the process of bringing higher units of force under more absolute control of the individual will. This is the new order of economy in production, as Prof. Hutton indicates, in which lies in great part the solution of the problem of increasing population.

* * *

On the material side the advance of the era is strikingly evident. It shows first, perhaps, in the vast manufacturing establishments, some of the greatest of which are described and pictured in this volume, and in the parallel rise of huge central power and lighting stations, swift steamships, fast railway trains, extended traction systems, great office buildings. Next, it shows in the change in the mechanical equipment of all of these – a change amounting to a revolution, especially in the tools of production used in the mill and machine works, impressive examples of which are given by Mr. Porter. Surely it must be apparent that there must be an equal progress in the system of co-ordination by which these tremendous agencies are made to work in internal and external harmony—in other words, in methods of management—and this, as has recently

been pointed out in these pages, not as an auxiliary to, but as an integral part of, the modern system of production.

The development of works management into a specialised branch of productive activity is indeed the great co-ordinate of the mechanical progress of the last few years, and it is to the founding of the recognised literature of this new applied science—to the formulation of the principles of Industrial Engineering—that this special number of THE ENGINEERING MAGAZINE is dedicated. And the resultant volume surpasses any former effort of the sort because the theme is richer in possibilities—because a great movement in human activity, full of the stirrings of vital power, is greater than any event, even one so full of meaning as a world's exposition.

* * *

Each new field of creative work has brought out a new army of specially trained workers, making a new section of the engineering profession. With the first uses of power began the differentiation of mechanical engineering, later subdivided still further into special sections; more recently still, the insistent demands of electricity raised up the new profession of the electrical engineer. But, as Mr. Gunn points out in another part of this magazine, these workers deal rather with processes and mechanical methods. The definite adjustment of these to commercial ends—the combination and adjustment of the productions of the civil engineer, the mechanical engineer, the electrical engineer, the architect, with the many human agencies employed, so that, as Mr. Orcutt argues, the whole works shall operate smoothly and efficiently as one great tool in which the various men and machines are the moving parts—this has become a new applied science, and Industrial or Production Engineering demands from the twentieth century due recognition as an equal member of the great family of engineering sciences to which the world owes so much. Like its fellows, it has application in every department of profitable industry. In the machine-shop, the power-plant, the railway, the mine—the processes of selection, co-ordination, supervision, and recording with which it concerns itself are absolutely demanded by the conditions and the vast scale of present-day workings. Regarded subjectively it is highly-specialised; regarded objectively, it is most widely general. And in the fullest sense it fulfills the definition of engineering, "Directing the forces of nature to the use and convenience of man," and that other somewhat less-quoted one, "Common sense applied to the use of materials."

* * *

That it is an exact science must be evident to anyone reading in these pages; the fundamental propositions are already crystallised into theorems accepted by all its professors. If these professors are not yet recognised as a distinct body, it is only because, as Mr. Gunn says, their science has awaited the creation of a literature—perhaps it would be more nearly correct to say the codification of its principles in literary form. Action has proceeded so rapidly that it has almost outrun its chroniclers, and is to be found in the concrete in practice more easily than in formulation in treatises. But in the forefront of its progress certain examples stand clearly typical of its best principles, and among its disciples certain leaders find the opportunity to epitomise their conclusions, and in the records of example and precept the literature of Production Engineering begins to assume volume.

And that literature it is the function of THE ENGINEERING MAGAZINE to embody. For four years the library has been accumulating. In this first issue of the Twentieth Century, the Magazine presents, in this special Works Management Number, the first great conference of the world's leading authorities on Production Engineering.

REVIEW OF THE BRITISH PRESS

The Capacity of Railway Wagons.

An important matter in connection with the much-discussed question of American competition lies in the relatively lower cost of transport in the United States over that in Great Britain. This difference is claimed to be due to various causes, but one of the most important is that of the greater capacity of the wagons, or, as they are called in the States, of the cars. The question of the capacity of railway wagons as affecting the cost of transport forms the subject of a paper presented before the Institution of Mechanical Engineers, by Mr. J. D. Twinberrow, and in the present state of railway transport in the United Kingdom the subject is especially timely.

An examination of the reports of railway working in the annual report of the Board of Trade shows that the increase of capital is nearly double that of the growth of the amount available for meeting interest charges. Diagrams plotted from the data given in the report show that the earning capacity of trains is slightly less, whilst the cost of working them is increasing. Any improvements which may have been effected in the construction of locomotives and rolling stock and in engineering practice have not been of sufficient moment to counteract the increasing cost of fuel and materials. "The principal factor in reducing the cost of a product is the economy of labour in its manipulation, and this is effected in modern industries by improvements in plant or tools whereby both the output and the remuneration of labour are increased; the results of railway working in the British Isles afford no evidence of the adoption of that principle to this important branch of industry. The useful product of railway working is the passenger or ton-mile; since these units determine the earnings, they should also form the basis for calculating the costs; but it is customary to refer the expenses of British railways to the arbitrary and unmechanical unit of the train-mile. This naturally tends to direct effort to the reduction of costs per train-mile rather than toward developments of which the immediate effect may be an increased cost per train-mile, though the final ratio of earnings to costs is improved. The ratio may be improved in two ways, firstly, by refining to the utmost possible extent the stock and plant employed to work trains of constant earning capacity; or, secondly, by the efficient utilisation of machinery and vehicles of greater earning capacity, permitting the realisation of larger receipts per train-mile."

As an example of the gain to be made by the use of wagons of large capacity, the question of mineral traffic may be taken. This traffic constitutes nearly three-fourths of the bulk, but yields little more than three-eighths of the revenue, because of the lower rates and shorter hauls. Any saving which can be effected in the tare weight of the vehicles employed in this class of traffic will permit of an equal addition to the paying load without increasing the cost of working. At the present time the average tare weight is about 39 per cent. of the gross load, so that 61 tons out of every 100 tons of full trains are paying freight. If one-third of this dead weight is saved by the introduction of wagons of increased capacity the tare is reduced to 26 per cent., which is equivalent to an advance of 21 per cent. of gross receipts. The gain is probably not so great in the carriage of general merchandise as in the mineral traffic, but it is enough to demand serious consideration.

In Mr. Twinberrow's paper a number of designs for wagons of heavy capacity are given, and the especial points demanded in construction are pointed out. The enlarged capacity must be obtained chiefly by increasing the length, and vehicles of the four-wheeled type will thus have a wheel-base so great as to occasion some difficulty on curves and turnouts. Short turntables

and traversers must also be removed and replaced with larger. Some designs are given in which it is proposed to use a cantilever extension truck, in order to avoid the objections due to length of wheelbase.

The adoption of the bogie system eliminates the objections due to sharp curvature, and is doubtless the best type for vehicles of heavy capacity, but this necessitates the removal of turntables, and the alteration of terminal plant, which includes hoists, tips, and lifts having short platforms. Designs for a variety of such wagons are given in the paper, as well as details of the changes involved in terminals, with especial reference to the transport and discharge of coal to yards, industrial establishments and ships. The successful introduction of high capacity wagons, either of the four-wheeled type, as tried on the Great Western and London & North-Western Railways, or of the eight-wheeled bogie pattern, is entirely dependent upon a satisfactory solution of the question of terminals. The substantial economies promised will doubtless justify a very considerable expenditure of capital in the alteration of existing plant; but the carrying out of such a change without interfering with the normal course of trade will demand careful consideration, and as many of the terminals where the loading and unloading are carried on are private property, it is not probable that the owners will incur the cost of alteration to suit an innovation, from which the railways will be the immediate gainers.

The Profession of Electrical Engineering.

THE inaugural address of Professor Perry before the Institution of Electrical Engineers upon the future status of the electrical engineer contains so much of general value and interest that no excuse is needed for reviewing it fully in this place. Everything Professor Perry says is so much to the point that the address is worthy of careful reading throughout, and only the salient points can be discussed here.

In the first place he puts the question: "Is the institution to continue to be a society for the advancement of knowledge in the applications of scientific principles to electrical industries, or is it to become a mere trades union?" Rapidly running over the status of other professional societies, notably the Institution of Civil Engineers, the differences between this venerable institution and other similar bodies are shown. Particularly to be noted is the discrimination between professional engineers and those who also include contracting work in their business, and while this discrimination may be desirable in the civil engineering profession it is hardly practicable in electrical engineering. It must be admitted that manufacturers and contractors and their employees may belong to the highest ranks of the profession, and that when thus qualified they should be welcome and desirable members. It is when the engineer deteriorates into a mere imitator that he becomes a tradesman, and Professor Perry thinks that unless due care is taken this degeneration is especially to be feared in the domain of electrical engineering.

"In railway, and harbour, and river and sanitary engineering in every new job there are new difficulties to be dealt with. An engineer who designs many undertakings and sees them carried out must be a thoughtful man; he cannot help keeping himself acquainted with engineering principles, and so he is a professional man. So an architect finds that each new job requires all his experience. Every case that comes before a real physician or surgeon requires a somewhat different treatment from any old case. Every case brought before a barrister requires all the exercise of all his past experience. In every case a *profession* implies the necessity for the exercise of all one's past experience, because the work one has to do is never the same as any work one has ever done before."

When the work becomes such a routine that it does not involve the exercise of this original thought and study, it may still be good and valuable work, but it is not professional work, it becomes trade work, and as such must be so considered. This state of affairs can hardly exist with the civil engineer; the conditions of his work are too varying; he must meet and control all kinds of natural difficulties.

"Now, of all such natural difficulties the consulting or contracting electrical engineer is greatly independent. Give him a source of power and tell him what is to be done; whether he is to light a town or a building, whether with arc or incandescent

lights; whether he drives a stamp mill near a mine or a pump, or a machine tool, or a spinning frame, the electrical part of the work is carried out in much the same way. Natural conditions affect him mainly in the cost of transport of his materials and the cost of labour. He can make in an easy way the most careful calculations as to the best arrangement of his conductors and machines to give maximum economy, and except for this easy calculation his work is that of a mere tradesman. He is practically independent even of the weather. There are, indeed, some of us who grumble that this easy calculation is not made easier still, who prefer to make arithmetical guesses rather than exact calculation, because, perhaps, we like to see a little uncertainty introduced into the problem to make it more like a problem in civil engineering. I want members to see clearly that as time goes on, as our electrical engineering work gets more and more cut and dried, the man who loses the power to calculate, who loses his grip of the simple theory underlying our work, must sink more and more into the position of a mere tradesman who has no longer the right to call himself an engineer."

At the same time the question of standardisation must be considered, but care must be taken that standardisation does not become a hindrance instead of a help.

"And so, although we are all agreed that much standardisation in our contrivances and methods is absolutely necessary for our competition with other nations, we must follow the Americans in this matter and take care that it does not destroy invention. Of course, when things are ready standardised, when we have our perfect Mauser rifle, or dynamo, or locomotive, or traction engine, or electrically-driven stamp mill, a Boer can buy or even manufacture them if he has money, and he can use them as well as, or possibly better, than we can. But he is not an engineer. He uses things after the engineer has done his work upon them. A stoker, a common engine-driver, the guard of a train, these are not engineers. You must have noticed that the American engineers, who surely deserve the character of being practical idealists above all other engineers, are the men who are most imbued with notions of standardisation which lead to cheapness of manufacture, and they are also the men most alive to the necessity for occasional extensive scrapping of types of machinery when they become even a little antiquated."

This important subject of "scrapping" has not yet received the attention in England which it really demands, and the paper of Mr. H. F. J. Porter, in another place in this issue, gives some notable instances of the manner in which the firms which have entered in competition with Great Britain for the markets of the world have ruthlessly sacrificed tools and plant apparently fit for many years of good service.

Professor Perry discusses the question of engineering education with his usual force and ability, and, as might be expected, he strikes a blow for the proper teaching and use of mathematics. With this comes a warning for those successful practitioners who are content to settle down complacently, forgetting what little theory they did possess, and in a few years find themselves passed in the race by new and younger men possessed of later and better knowledge. That the abstract and theoretical science of to-day becomes the practice of to-morrow no one knows better than Professor Perry, and his peroration is a strong appeal for the co-operation of the institution in the scientific work of the present, for the value which it is to have for the future.

"Engineers descended from men who sneered at Cavendish and Franklin, and Volta, and Oersted and Ohm and Faraday, are you, who utilise the results of the work so sneered at and pile up fortunes in consequence of it—are you the men to sneer at and ridicule the scientific work of the present day because it seems to you useless?

"Tell us a better method of observation; give us better suggestions as to what these magnetic phenomena may mean; but the past record of scientific observation enables us to laugh at you when you say that magnetic observations may never give the world any important results. Was Nature ever so open and yet so closed about a secret as she is about this one of terrestial magnetism? Was there ever one whose revelation promised so much? How very little

we know of electricity and magnetism! Does the mere motion of the earth, taking no account of electric changes at all, cause it to be magnetic? Almost everything is on the cards. Surely I need not appeal to your cupidity, but it is quite possible that our knowledge of this secret may enable us to trap a tremendous store of Nature's energy.

"Gentlemen, this is not a trades union, and it is not a society for the furtherance of pure scientific research, but it is a society of professional men who recognise the past services of scientific observers with gratitude and respect, and hope for greater ones in the future. And shall it be said of us that our gratitude is not greater than that of Judas, to whom, indeed, thirty pieces of silver was doubtless a large sum; that 'we have given our hearts away a sordid boon'; and that as to our future hopes we are willing to sell our birthright for a mess of pottage?"

Steam and Electric Locomotives.

THE question of the supersession of steam locomotives by electrically hauled trains has long been a subject of popular discussion, but apparently there has been but little done toward accomplishing that end. Various reasons have been assigned for the comparatively little progress which has been made in this direction, and the matter hardly appears to have been considered seriously by the great railway companies.

The paper of Mr. W. Langdon, recently read before the Institution of Electrical Engineers, examines the subject in detail, and is worthy of especial notice at the present time. Mr. Langdon declares one of the most interesting questions associated with the application of electrical energy to railway work to be the eventual suppression of the steam locomotive. At the same time he admits that there has been no material progress towards this end, although a number of powerful electric locomotives have been constructed and are at present in use upon special work. Such electric locomotives as are at present in use have been adopted for some especial reason, such as the avoidance of smoke at or near a terminal. Notable examples of this are seen in the extension of the Orleans Railway to its new terminal in Paris, and in the case of the Baltimore & Ohio tunnel in the United States.

Because the electric locomotive has been so employed, and its employment has been attended with marked success, it does not follow, however much it may appear desirable, that in overland railways electricity will in future prove to be the element of power. Railways are commercial undertakings, in which vast sums of money have been embarked, all of which, investors expect, will produce a certain annual return. The supersession of steam by the electric locomotive thus resolves itself, primarily, into one of profit and loss. If its adoption will enable railways to be worked more economically than is the case under steam, then it will, with its attendant advantages, sooner or later, be adopted—if not by the whole, certainly by the greater portion of the railways of the country; but whatever the ulterior advantages may be, unattended by this result, its adoption will remain doubtful.

Mr. Langdon thinks we are in a position at the present time to consider this subject intelligently. We know how many pounds of steam can be obtained from a given quantity of coal, and the losses attendant upon its conversion into electricity and the subsequent transmission, distribution, and application are readily ascertainable. He therefore proceeds to tabulate the data available for the determination of the power required for the operation of steam railways and the cost, and to compare this with the computed cost of working the same roads by electric power, with favorable conclusions.

As a matter of fact, it hardly appears possible to make any such comparison, because the evolution of electric traction will probably be on such different lines from those of steam railway systems as to render the two utterly unlike. When steam railways were first started there came the inevitable comparison with the older stage coach system, and the present form of compartment railway carriage, used in England and on the Continent, bears witness to the early attempts to produce a railway carriage by placing several stage-coach bodies upon a framework supported by the running gear.

Instead of a mere replacement of the electric locomotive by an electric engine

hauling similar trains, the coming electric railway is far more likely to be a development of the independent trolley line. The train is a mechanical necessity of the conditions of steam traction, for when the whole power house is to be carried along in the form of a locomotive, with boiler, engine, fuel, attendants, water, etc., it becomes necessary to limit the number of such machines by compelling each to haul as much as possible. With the electric motor these conditions are entirely changed. The generating plant is entirely stationary, and the only portion required to be transported is the motor. This renders it possible to run frequent elements, or combinations of elements, as the traffic may dictate; and the whole train system, with the necessity for the locomotive, is open to change and modification. Much of the time now lost by waiting for trains, or by neglecting important matters in order to catch trains, may be avoided when an almost continuous succession of cars is maintained in operation between important cities. The intermittent system may be transformed into a veritable flow of passengers and merchandise, with the result that one may go to the nearest station without regard to the time and find transportation in a few minutes.

Such a change would involve the scrapping of the locomotives and rolling stock of railways conducted under the present train system, but scrapping, as Professor Perry more than hinted at in his address reviewed elsewhere, is something which must be learned if progress is to be made. The juggling with the train mile and the ton mile, so well known to railway managers in the fixing of rates and the computation of costs, would give way to a more rational system of charges based upon the actual cost of performing the service, and with the abolition of the intermittent train, and the advent of the continuous flow of traffic, the whole system of transport would be changed.

That this is at all probable in the near future it is impossible to say, for the opposition, both open and covert, of the existing railway systems is a powerful element which cannot be subject to computation. At the same time, history repeats itself, and there have been many instances in which an apparently powerful industrial organisation has been demolished by the advent of a new and more powerful successor, and unless the steam railways are prepared to do the thing themselves, they may find it done by others, when it has passed forever out of their control.

Liquid Fuel.

ALTHOUGH liquid fuel has been in use for many years in the steamships and railways of the Black and Caspian Sea district, it is only recently that supplies could be depended on at points on the various steamship routes with sufficient certainty to permit vessels to be equipped with apparatus for using liquid fuel under the boilers to the exclusion of coal. At the present time the number of places along the eastern route at which liquid fuel can be obtained has increased so enormously that it has become a question for shipowners to consider whether it is not an absolute economy to use it in preference to coal on vessels trading to the eastward.

For this reason the paper of Mr. E. L. Orde, recently presented before the North-East Coast Institution of Engineers and Shipbuilders, discussing the whole subject of liquid fuel, is timely.

Naturally, the principal question involved in the matter lies in the cost of the fuel and its calorific value as compared with coal. The effect of the fuel on the life of the boiler furnaces in which it is burnt must also be considered, as well as the immunity from danger.

Leaving aside the question of the cost of the fuel, which naturally involves commercial rather than engineering considerations, Mr. Orde proceeds to consider the practical calorific value of liquid fuel as compared with coal. This really resolves itself into the problem of the efficient combustion of the fuel, and it is to this subject that the paper is devoted. "The existing appliances designed for the purpose may be broadly divided into three:

"1st. Those in which the liquid fuel is injected into the furnace in the form of a spray by purely mechanical means.

"2. Those in which the spray is produced by the introduction of a gaseous medium.

"And 3d. Where the liquid fuel is intro-

duced into the furnace in the form of vapour."

"In the first type, the purely mechanical spray, the oil is discharged under pressure into what is commonly called a burner, which is made of such a form that the effluent jet is broken up into particles sufficiently small to burn readily at the firing point of the fuel. The full efficiency of the system can only be obtained by lining the furnace with fire-bricks, or other non-conducting material, so as to raise the furnace temperature (by preventing the absorption of heat into the boiler) until it is sufficiently high to vaporise the greater portion of the oil before it is burned. The quantity of air required to complete combustion is very largely in excess of what is chemically necessary, and the furnace space required for oxidation is large. The advantages of the system are: First, its simplicity, and, secondly, its noiselessness.

"As regards efficiency the best results that the writer has been able to find recorded show an evaporative efficiency of about 12.5 lbs. of water from and at 212° per lb. of oil. With Borneo oil this gives a fuel efficiency of 64.6 per cent.

In the second class the oil is introduced into the furnace in the form of a spray in the presence of a gaseous medium—be it steam or air. In most of these appliances a partial lining of fire brick is fitted in the furnace, and a brick bridge or baffles of various forms are built with a view of obtaining complete oxidation of the fuel. The earliest form of this apparatus consisted simply of two pipes lying one above the other, and having their ends flattened so as to spread the streams of oil and steam. Oil is admitted to the upper pipe and is allowed to drop from the orifice into the jet of steam which passes through the lower pipe and meeting the oil, breaks it up into particles sufficiently small to ignite as soon as the firing point is reached. This simple device has been improved upon by numbers of engineers, and most of the improved burners of this type take the form of concentric tubes, through which the oil and steam are passed. Adjusting arrangements are always provided, so that the supply of the two elements can be regulated at will. This type is better known than any other, and has, so far, given the best results. The evaporative efficiency of the best burners of this type seems to be about 13—14 lbs. from and at 212°, but the supply of air required for oxidation, though smaller than that demanded by the first-class of burner, is much above what is chemically necessary. The difference between steam and air as spraying media will be touched upon hereafter. The third class of apparatus, that is, in which the fuel oil is wholly or partially vaporised, promises to give the best results.

Experiments made with these various forms of apparatus, using Borneo oil as fuel, with a calorific value of 18,831 B. T. U., show that the efficiency of liquid fuel lies in the fact that it is capable of being turned into vapours of high calorific power, and that the vaporising process does not demand a large heat expenditure. On shipboard the use of steam atomizers has been objected to because of the loss of steam and the necessity of increased evaporator surface to provide fresh water for the boilers.

With air as a spraying agent, there is, of course, no loss of fresh water, but it is questionable whether the quantity of steam used in the air compressors is not greater than that required in the burners and evaporators together. The complete combustion of petroleum spray depends, firstly, on the correct relation between the volumes of the oil and the spraying agent, and, secondly, on the velocity of the spraying agent, both of which requirements place air at a considerable disadvantage as compared with the steam. The general conclusions deduced from the investigations Mr. Orde has made are as follows:

"1. Liquid fuel of good quality, such, for instance, as Borneo oil, used in boiler furnaces, if efficiently treated, should show a reduction in consumption of about 4 per cent. as compared with coal.

"2. A reduction in bunker space of about 15 per cent. for the same weight of fuel; a reduction of about 50 per cent. for the same radius of action.

"3. A reduction in the stokehold staff of at least 50 per cent."

The advantages of liquid fuel as regards ease of manipulation, cleanliness, absence of smoke, reduced temperature of stokehold as compared with coal, increased life of boilers owing to constant temperature,

improved performance of engines owing to constant steam pressure, are all now generally conceded.

So far as the question of danger is concerned, there is no risk of explosion with a fuel oil having a flash point of over 200° F., and the only danger of fire is that due to neglect. If the burning apparatus is permitted to become dirty, or if there is much water in the oil, the intermittent action may cause difficulty, but both of these causes of trouble are readily preventable, and with reasonable care may be altogether avoided.

Pure Drinking Water.

PURE water has always been considered one of the most essential elements for health and comfort, and the procuring and distribution of a satisfactory water supply has from the earliest times constituted an important portion of the work of the engineer.

It is therefore extremely appropriate that the address of the president, Mr. James Mansergh, before the Institution of Civil Engineers, should deal with the engineering problems of pure water supply, especially as it includes that branch of the profession with which he has been most actively identified.

On the question of purity, that is, the absence from the water of any such pathogenic organism, the responsibilities of the water engineer are daily becoming more onerous and exacting. We are thus now-a-days constantly confronted with the problem as to what assistance we can hope to obtain from the chemical and bacteriological examination of water respectively.

Now, the chemical examination enables the chemist to diagnose with more or less accuracy whether and in what degree the water has been contaminated with animal or vegetable substances. The signal service rendered by these methods in detecting sewage contamination is conspicuously reflected in the diminished mortality from typhoid and cholera in this country. There are, however, many waters—often available in very large volume—which are contaminated to such a slight extent only, that they differ but very little in chemical composition from waters obtained from unimpeachable sources; and the question has forced itself upon practical men, in view of the ever-increasing demands made by the growth of population, whether such waters must be wholly avoided or whether they cannot be rendered suitable for domestic purposes by submitting them to some simple process of purification, such as storage in large reservoirs, or filtration through fine sand.

But inasmuch as the changes effected in a water by sand filtration from a chemical point of view are quite insignificant, the nature of the services rendered by this method of treatment remained completely obscured, and were not revealed until comparatively recently, when the introduction of the now well-known bacteriological methods of water examination have enabled an entirely new interpretation to be placed upon such processes of purification. These new methods were brought to a high state of perfection some seventeen years ago by Robert Koch, and it was in the year 1885 that Percy Frankland first applied them to the investigation of the character of the purifying processes as actually practised by the London water companies. This investigation brought out the reassuring and totally unexpected fact that the processes employed were often successful in removing 98 per cent. of the bacteria present in the original water. These inquiries were also instrumental in placing these and other purification processes on a sound scientific basis. Thus among the several London companies dealing with the same unfiltered water, those companies achieved the best average result which stored the water for the longest period and filtered it at the slowest rate through the greatest depth of sand. The importance attributed to such examination is based on the supposition that most natural waters may at any time contain bacteria capable of producing disease, and we require a guarantee that any harmful forms which may be present should be prevented from reaching the consumer. This, in the present state of our knowledge, can be secured only by submitting the water to processes which effect the removal of *all* bacteria, irrespective of their harmful or harmless nature, and we therefore estimate the value of the process according to the efficiency with which it does this.

Mr. Mansergh, however, has the courage to express his doubts as the desirability of thus removing all the micro-organisms. It is common to assume that the majority are simply harmless, but it may be wiser to assume that they may be actively beneficent. The matter is not yet settled, and is under active discussion and criticism by physiologists and pathologists.

In line with the question of the procuring of pure water comes the matter of the sanitary control of the supply. Mr. Mansergh takes the occasion to assert his faith in the soundness of the principle that the purveying of water to the public should be one of the distinctive functions of the responsible sanitary authority of any district. This involves the discussion of the right to take over the ownership of private companies, and while this may seem a difficult matter to settle, it should be settled as Mr. Mansergh suggests, not upon a basis of sympathy, but upon common sense. Just how the most equitable system of arranging such questions is to be determined is not clearly stated, but a discussion of existing cases, notably of the eight companies now supplying London, forms the closing portion of the address, and may lead to a plan applicable also to other and similar problems.

Engineering in the British Navy.

THE appearance of Rear-Admiral Melville's report, with its criticism of the results of the operation of the personnel bill in the American Navy, is made the subject for an interesting editorial in a recent issue of the *Engineer* upon the broad subject of naval engineers in general, with the implied reference to the Royal Navy, which is the real subject under discussion.

It will be remembered that the change in the American Navy was intended to amalgamate all the officers into one corps, the line and the staff to be both instructed in engineering and to be given duties in control of the engineering details of the modern ship of war. The result has been that the former engineer officers have really become line officers, and the former line officers have not become engineers, and the vessels are consequently more short-handed in the engine room than ever.

The *Engineer*, in examining this question of the deficiency of capable engineer officers, falls back upon the idea that it is no more necessary to have educated and trained engineers in the engine room of naval vessels than in those of vessels in the steam merchant marine, or in a stationary power plant ashore, and that the true solution of the matter is to place the machinery in the hands of competent machinists, paying high enough remuneration to obtain the best possible service, in lieu of rank or naval standing.

This practically corresponds to the present grade of "warrant machinists" in the United States Navy, and may be a thoroughly practical and effective solution of the problem. The engines and machinery are built by machinists, and designed by working engineers, who know little and care less about military or naval rank, and consider their calling as a business. From this class of men the navy could certainly find recruits if the pay offered were a sufficient inducement, and there is little doubt that the experiment would be successful.

In this connection, however, the thought naturally arises, if the system of training and organising naval officers fails in such a critical feature, is there not something lacking about the whole organisation? Why have naval academies at all, if the work can be as well or better done by ordinary workmen, toiling, not for the glory of the cause, but for the more business-like reward of hard cash?

Again, if this system works well for the engine room, why may it not work well for the bridge and the turret? The modern great naval gun is as much a piece of machinery as the engine in the hold, and the art of navigation is not difficult of acquirement. Perhaps the turning of the engine room over to the warrant machinist may be a pregnant precedent, fraught with possibilities not altogether grasped by those now advocating it. The modern naval officer, whether of the line or the staff, may go the way of the mediæval knight into the oblivion of history and the museum, and the men who really do the work assume the credit and carry the responsibility as well.

REVIEW OF THE CONTINENTAL PRESS

Intensified Gas Lighting.

At the time of the introduction of electric lighting it was supposed in many quarters that gas-lighting was doomed, and for a time the decline in the shares of gas companies bore out this belief. The actual result has been a stimulus to inventors, and such marked improvements in the methods of using gas as an illuminant that it has more than held its own against the formidable competition thus encountered.

Among the notable features of the Paris Exposition the extensive use of gas lighting attracted much attention, and in a recent issue of *Le Génie Civil* an extended account of the improved methods there employed is given by M. J. Laverchère.

The Compagnie Parisienne du Gaz had reserved for its display the parks and gardens of the Champs de Mars and the Trocadéro, and desired to make as brilliant a showing as possible in the face of the elaborate electric lighting of other parts of the Exposition. In order to appreciate the advance which this display indicates, M. Laverchère first gives a brief résumé of the development of gas lighting in Paris since 1877, showing the steps which have led to the present practice.

In 1877 the gas lighting was accomplished by the use of bat-wing burners, used either singly or in groups, and consuming about 140 litres of gas per carcel per hour (about 0.48 cubic feet per candle power). When, in the same year, the Jablochkoff electric candle was introduced, the gas burners were improved by using a combination of tips aided by a stronger draught, and what was considered a notable improvement followed, an illumination of 13 carcels being produced with a gas consumption of 105 litres per carcel (0.39 cubic ft. per c. p.). In 1889 the regenerative gas burner was introduced on the avenue de l'Opera and the rue de la Paix, and to a limited extent at the Exposition of that year, the consumption of gas ranging from 50 to 75 litres per carcel-hour (0.18 to 0.26 cu. ft. per c. p.), single burners consuming from 150 to 1,200 litres per hour, and giving a proportional illumination. In 1885 the incandescent mantle was invented by Dr. Auer von Welsbach, but it was not until the close of 1891 that it was manufactured in commercial form. The Welsbach burners of that date were of two sizes, the first consuming 80 litres of gas and giving a light of 4 carcels (0.073 cu. ft. per c. p.), the second requiring 120 litres of gas, and giving a light of 6 carcels; the same consumption per unit of illumination.

Since 1894 incandescent gas burners have been in use in the lighting of Paris, but during the time preceding the Exposition investigations have been conducted with a view of producing more powerful units of illumination. The result was the adoption of the Bandsept type of Welsbach burner, of 22 carcels, burning 300 litres per hour (about 0.05 cu. ft. per c. p.) under a pressure of 70 m m. of water (2.75 inches), for the Champ de Mars, while for the park of the Trocadéro the Denayrouze burner, consuming 270 litres per hour, requiring about 20 litres per carcel (0.073 cu. ft. per c. p.) was adopted. These burners, it will be observed, represent units of 125 to more than 200 candle power, and their installation in this conspicuous manner gave opportunity for useful comparison and study. It was, therefore, decided to operate a portion of the burners with gas at the ordinary pressure, and others with intensified pressure, in order that the effects might be seen. The Bunsen burner, upon which the incandescent lamps depend for their action, provides for the admixture of the necessary quantity of air when only a moderate quantity of gas is to be burned. When, however, an increased consumption is demanded, it is necessary to furnish an increased pressure, either of air or of gas. In order to avoid the necessity of a separate system of pipes to convey air under pres-

sure, the increased pressure was given to the gas, the air being supplied as usual.

The increase in gas pressure, practically fixed at 200 m. m. (about 7.87 inches) of water, is to accomplish two objects:

1. To enable a consumption of 350 litres per hour (12.36 cubic feet) to be effected for each mantle.

2. To insure an illuminating efficiency of 9 to 10 litres per carcel (0.033 to 0.037 cu. ft. per c. p.) per hour.

Under these conditions an illumination of 35 to 38 carcels is attained by a single mantle, corresponding to 332 to 361 candle power. The compression was effected by two rotary compressors, each driven by an 8 horse-power gas engine, each set having a capacity of 1,200 cubic metres per hour.

The paper of M. Laverchère is copiously illustrated, showing the installation and operation of the plant, as well as the disposition of the burners, and much useful information as to this latest and most powerful example of intensified gas lighting is given.

The general results show that there were in use 4.619 incandescent mantles, of which nearly one-half were operated at the high pressure, consuming 1,383.200 litres of gas (48,800 cu. ft.) per hour, and giving an illuminating intensity of 91,000 carcels (about 864.500 candle power), with an efficiency of 15.2 litres per carcel (0.056 cu. ft. per c. p.).

The Strength of Boiler Shells.

It might be supposed that such an apparently simple mechanical problem as the computation of the strength of a cylindrical shell subjected to internal pressure hardly deserved especial discussion notice, but as a matter of fact there are a number of points connected with it which are too often neglected. For this reason the paper of Herr Walter Conrad in a recent issue of the *Zeitschr. des Oesterr. Ingenieur und Architekten Vereines* is worthy of note, and some of the points made by him are of interest.

Herr Conrad points out that the real difficulties in the computation of the strength of boiler shells are those which arise from the introduction of conditions which the ordinary rules do not take into account. The boiler is usually considered as a truly cylindrical shell, of homogeneous material, of uniform thickness, free from holes, none of which conditions appears in actual practice. It is not surprising, therefore, that strength determined by computations in which so many controlling conditions are neglected must be looked upon with doubt. The usual answer is that all these points are provided for in the so-called factor of safety, or as it has sometimes been called, factor of ignorance. Herr Conrad prefers to do otherwise, and attempts to compute the weakening effect of the hole which must be cut in the plate; also the influence of hard and soft spots in the metal, and of the effect of deviations from the true cylindrical form.

Considering first the weakening effect of holes cut in the shell, Herr Conrad calls attention to the usual idea that the reduction in strength due to the cutting of the hole may be entirely offset by riveting a ring of metal around the opening, and proceeds to examine to what extent this is true. Taking the formulas of Grashof and the mathematical discussion of Holzmüller, it is shown that the circumferential stress at the edge of a hole cut in a shell is equal to double the stress in the uncut plate, and that this relation holds good independently of the diameter of the hole. This gives a simple method of computing the proper reinforcing rings, and Herr Conrad recommends the use of two rings, one within and the other without the shell, giving a much greater reinforcement than is usually considered necessary.

Defects in homogeneity, due to the presence of hard or soft spots in the metal, are necessarily difficult to subject to computation, owing to the irregular shape and indeterminate outline, and can only be properly investigated by the aid of the testing machine.

When a hole in a shell is surmounted by a dome it is desirable to be able to compute the strengthening effect of the addition, and in most cases it is wise to neglect the effect of the body of the dome, as it is of but small value, leaving only for consideration the reinforcing action of the flange, this being considered as a simple ring, and similarly computed.

Boiler shells are rarely of true cylindrical form, and hence the true stresses are cor-

respondingly difficult of precise determination. Herr Conrad discusses the effect of moderate degrees of ellipticity under various pressures and tabulates the results for practical cases. In this way he gives permissible degrees of ellipticity which do not permit a greater increase in stress than 10 per cent. above that due to cylindrical shells. These computations are based upon true ellipses, which are seldom met with in practice, and it is reserved for experimental determination to show that other deformations do not produce greater stresses.

In conclusion Herr Conrad examines the permissible limits of the factor of safety to be used in boiler computations. He concludes that for the present pressures of about 100 pounds per square inch, a factor of safety of 5 is desirable, but that with the pressure of 150 pounds, to be expected as common in the near future, a factor of 4 will be sufficient.

A further paper is promised, to contain the result of experimental investigations.

The Distribution of Steam in Compound Locomotives.

COMPOUNDING is now so generally applied to locomotives that an examination of the steam distribution is a matter of importance, and a very full discussion of the subject in a recent issue of *La Revue Technique* demands review.

In order that a good action be obtained it is now generally conceded that the admission should be more prolonged in the large cylinder than in the small one. In this manner the work of the high and low-pressure cylinders may be equalised when their relative volumes are properly proportioned. This is especially important in the case of two-cylinder compounds, and is less material in the four-cylinder compound engines, whether the motors are connected to one or two axles. With a prolonged admission in the low-pressure cylinder it is possible to attain a high speed with easy running. The compression in the high pressure cylinder is reduced, and for the same admission in the latter the weight of steam consumed is increased, and consequently a greater amount of work developed. The degree of wire-drawing in the low-pressure cylinder is also reduced, and consequently a higher economy is attained.

On the other hand, the prolongation of the admission in the low-pressure cylinder depends upon circumstances. It should be controlled by the opening of the throttle, by the degree of admission in the high-pressure cylinder, and, above all, by the speed. It must, therefore, be variable according to these varying conditions, and hence there have been, especially in France, many efforts to provide compound locomotives with valve gear permitting the admission in the high and low-pressure cylinders to be varied according to the circumstances of the work.

Naturally such a problem has been attacked in various ways. In some cases the two cylinders are provided with entirely independent valve gears, permitting the widest latitude of adjustment, but also involving the greatest degree of complication in construction and operation. In other cases the valve gears are combined and operated together, both cylinders varying the degree of admission according to the position of the lever. Another arrangement provides for a constant degree of admission, say 60 per cent. in the low-pressure cylinder, the two distributions being otherwise connected.

The arrangements in practical operation, however, may be broadly divided into two classes, based upon the modifications in the valves of the two cylinders. Either the lap on the valve of the low-pressure cylinder is reduced, and the angular advance correspondingly diminished; or, the lap may be made the same on both valves, no difference being made in the angular advance, the relative travel alone being modified.

In the discussion above referred to, the methods of employing these two methods are graphically examined, using for the purpose the well-known Zeuner diagram, and considering the Walschaert valve gear and its various modifications as best adapted for the purpose.

In many instances two distinct valve gears are not necessary, there being instead a double link and a separate valve rod for each valve, so that the valves may be operated from different parts of the link. Examples of such arrangements were seen on different engines exhibited at Vincennes during the Paris Exposition, and the action

is shown by diagrams in the original article. It is impossible to give the details of the analysis in this place, but in the original paper a number of practical examples are worked out and their application shown. The degree of flexibility thus obtained cannot fail to add to the ease and effectiveness of the locomotive, and the whole subject shows the advantages of compound engines thus equipped, in addition to the economy of compound over simple locomotives.

Continental practice has given the Walschaert gear such an exhaustive trial that its general advantages over other forms of locomotive valve gear have stood the test well, and it is a matter of surprise that it has been so little used in England and America. The ease with which it lends itself to the accomplishment of a variable steam distribution in the two cylinders of compound locomotives forms an additional recommendation to this simple and ingenious gear, and in the light of present experience in France, Germany, Belgium, and Switzerland, as emphasised by the fine engines exhibited at Paris, it is possible that the present universal judgment in favour of the ordinary link motion may be revised and modified.

Elastic Limit and Ultimate Strength.

ONE of the most important matters within the whole domain of engineering practice is a study of the properties of the materials of construction, with a view of ascertaining their strength or weakness. The whole subject of the testing of materials is recognised as of controlling importance, since the selection of a material and the proportions of the members in which it is used form fundamental elements in engineering design.

Formerly it was thought sufficient to subject a specimen of the material to be used to a stress sufficiently great to produce rupture, and then to allow a factor of safety, or determinate fraction of the breaking load as the safe working stress. Experience, however, showed that the ultimate strength did not always furnish the desired knowledge of the safe use of a material, and the importance of a knowledge of the limit of elasticity, or the stress beyond which extension ceased to be proportional to stress, began to be realised.

The question of the relation of the elastic limit to the ultimate strength of a material forms the subject of an interesting discussion in the *Zeitschrift des Vereines deutscher Ingenieure*, by Professor Mohr, of Dresden, and while the mathematical nature of his treatment prevents a presentation of his full discussion in these columns, yet his conclusions and the reasoning on which they are based may be briefly reviewed. Professor Mohr recognises that this important question cannot be answered by theoretical reasoning alone, and shows that actual tests and experiments must be used to verify the conclusions deduced from theoretical considerations.

The analytical investigation of Professor Mohr is really based upon a graphical study of the alteration in form of an elementary molecule of the body under consideration, when subjected to a stress within the elastic limit. The older hypothesis, which made the elastic limit a definite proportion of the ultimate strength, is also considered.

In discussing the data for the foundation for a modern theory, Professor Mohr considers that the limit of elasticity is that of the stress which causes internal sliding of the layers of the material upon each other, while the ultimate strength depends upon the resistance of these same layers to rupture. When the limit of elasticity or of rupture has been exceeded in any portion of a body, motion takes place in the direction of the resultant of the stresses, and the direction and magnitude of this motion is examined by the aid of graphical diagrams. in accordance with the analytical theory.

The manner in which the internal deformations actually occur may be studied by polishing the surfaces of metals which have been subjected to stresses exceeding the elastic limit, and examining the lines and figures which appear thereon. The markings are especially brought out by heating the metal to such a degree as to cause the formation of oxide, and the molecular deformation is in many instances very clearly shown. The peculiar markings which appear when the elastic limit has been passed show that there has occurred a flow or sliding of the various portions of the metal upon each other, and the intersections of the planes in which this sliding has taken

place appear as lines of flow upon the surface of the specimen.

According to the theory of Professor Mohr, the elastic limit and the ultimate resistance depend upon the stresses existing in the layers in which sliding and rupture occur, and the resultant of these forces enables the relation between the two limits to be determined.

In the case of a round rod pulled in the testing machine, the reduction of cross-section shows very clearly the action of opposing forces, acting to extend the length and at the same time to reduce the diameter of the extended portion. We here have axial and radial forces acting at the same time upon the material, and the nature of the fracture shows the manner in which the material responded. On the end of the fractured piece are seen the radial lines in the direction in which the rupture took place, while the axial markings show the sliding which occurred. As these relations vary under different conditions, it is apparently erroneous to assume directly that the elastic limit bears a definite relation to the ultimate strength. The immediate conclusion is that the conditions under which the stresses are applied should be taken into account, and that, whenever possible, the material should be tested under conditions analagous to those under which it is to be used.

Professor Mohr refers to the investigations of Mr. J. J. Guest, in England, as sustaining his views, although he had no knowledge of these at the time of his own researches, and the whole subject appears to be opened up anew in a manner which may lead to a more intelligent study of the strength of materials of construction.

Power Gas Development.

THE continued interest in the development in the question of the utilization of lean gases produced in metallurgical operations as a source of power is shown in the attention which is given to the subject in the technical press, especially in Germany and in Belgium. We have in a recent issue of the *Zeitschrift des Vereines deutscher Ingenieure,* a publication of the paper recently presented before the society by Herr A. Wagener, followed by a further discussion of the subject by the same engineer in the pages of *Stahl und Eisen,* giving the latest developments of practice in an interesting manner.

Herr Wagener credits Mr. Thwaite with the first attempts to use furnace gases in internal combustion motors, citing the experiments in the autumn of 1894, these being soon followed by the work of the Hörde Iron Works in 1895, and by numerous installations in various parts of Europe. The existing forms of gas engine at the time of the proposal to use furnace gases were designed for the use of illuminating gas, a fuel of 5 to 6 times the calorific power of the lean gas discharged from blast furnaces, and in most cases the engines were of comparatively small size. Since the first application of engines at iron works in the production of the blast, it has been necessary to design large engines, from 600 to 1,000 horse power, and to so proportion them as to be adapted for the lean gas of the furnaces as their fuel.

Herr Wagener gives special attention to the engines of the Oechelhaüser type, and illustrates its construction by detailed drawings, showing the applicability of these large gas engines for direct connection to blowing cylinders and also to the driving of electric generators. Owing to the large surplus of power which may be generated by the gas from a furnace, over and above that required for the production of the blast, it is especially desirable that electric driving be introduced, since practically all the power required, as well as the lighting, may thus be obtained from the use of the gases, without the necessity of employing steam boilers and engines.

Although Herr Wagener devotes the greater part of his discussion to the recent installations of the Oechelhaüser engine, he calls attention to the general development in the building of large gas engines resulting from the appreciation in recent years of the economy of this type of motor, and its adaptability to a fuel otherwise wasted. Not only the original gas engine works of Otto, at Deutz, but also the establishments of Körting, the Berlin-Anhalt Works, the Aschersleben Works, the Augsburg Works, the Cockerill Works, and a number of others, have undertaken the regular manufacture of large gas engines adapted for use with lean gas. The pre-

diction of a prominent German engineer, made only a few years ago, that the gas engine builders would not be able to supply the machines to utilise the vast volumes of furnace gas then thrown to waste, has fallen so far short of the fact that it has been demonstrated that motors of this type are to be reckoned with as a standard article of manufacture. As a matter of fact, a number of large steam-engine building works have already undertaken the construction of gas engines, and others are preparing to add a line of such motors to their product.

One of the important results of the display of gas engines at the Paris Exposition is the realisation on the part of engine builders that there is nothing mysterious or difficult about the construction of such motors. As a matter of fact, there is less complication and difficulty than with the more highly organised forms of steam engine, and as the fluid with which they are operated is permanent, as opposed to the condensible steam, the thermal economy is much less readily affected by variations in design than with the steam engine.

In view of the fact that the fundamental principles of gas engine construction are open to the world, and also taking into consideration the growing practical interest in such motors, a very rapid development in this branch of industry may be predicted.

It is of especial interest to note that the development of internal combustion motors at the present time is mainly directed toward two extremes; the large motors, of 200 or 500 horse power, and upwards, and the very small motors, of 2 to 10 horse power, for motor vehicles. With the exception of minor details of construction, due to the peculiar conditions of operation, the construction of both classes is identical, and, furthermore, the thermal economy of the small motors is nearly as high as that of the larger ones, the great obstacle to economy of small steam engines, internal condensation, being absent in motors operating with permanent gases.

The Work on the Simplon Tunnel.

FROM time to time the project of a tunnel at the Simplon Pass between northern Italy and western Switzerland has been discussed in these columns, and as the progress of the work has been recorded in current technical literature the accounts have here been reviewed. The exhibit of the work made at the Paris Exposition has been made the occasion of a very complete review of the whole undertaking by M. A. Dumas, in a recent issue of *Le Génie Civil*, and the magnitude of the work renders further notice at this time desirable.

The massive ridge of the Alps known as the Simplon has long obstructed travel by rail between Italy and western Switzerland, although the present highway road was constructed over the pass by Napoleon I. between 1800 and 1806, at a cost of 18,000,000 francs. For nearly fifty years the idea of piercing the mountains by a tunnel had been considered, and a number of plans proposed and discussed, but the cost of the work rendered the commencement a matter for repeated delay. The growth of traffic, and the gain in distance by creating this connection in the route from Paris to Suez and in general between Italy and the North Sea coast, however, has changed conditions to such an extent that the advantages of the tunnel became too evident to be neglected, and the work has now been under way for more than two years.

Much of the preliminary work which preceded the actual commencement of operations was devoted to the financial development of the work, subsidies being obtained from both the Swiss and Italian governments by the Jura-Simplon Railway, and a concession was secured for a period of 99 years, the total cost being estimated at 69,500,000 francs.

As already explained in these columns, the plan for the tunnel differs from the existing Alpine tunnels in that two bores, each for a single track, are planned in place of one double track tunnel. This idea possesses a number of advantages. In the first place, the quantity of excavation required is less, even if the work were all done at one time, but the great feature of the system is that it enables one tunnel to be completed first, while the other may be added when the traffic shall demand it. In the meantime a small passage is to be pierced on the line of the second tunnel, and used for the purpose of drainage and ventilation of the completed section, this passage being con-

nected by cross openings to the first tunnel at regular intervals. The enlargement of the second tunnel to the full size may then be made at any subsequent time without interfering with traffic on the completed part.

In length the Simplon tunnel exceeds any of its predecessors, the principal Alpine tunnels being as follows:

	Length.	Altitude.
Mont Cenis..	12,849 metres	2,949 metres
St. Gothard...	14,984 "	2,861 "
Arlberg	10,240 "	2,030 "
Simplon	19,731 "	2,840 "

An important feature in connection with the work lies in the abundant supply of water under pressure, which renders the employment of hydraulic drills practicable. The water used for the purpose is taken from the Rhone, being brought a distance of 4½ kilometres through an aqueduct of reinforced cement, constructed on the Hennebique system, the delivery being 5 cubic metres per second under a head of 44.6 metres, and furnishing 2,230 effective horse power on the shafts of the turbines.

Owing to the possession of ample power, and also because of the use of modern high explosives, the time for the completion of the tunnel is expected to be proportionally much shorter than was the case of the earlier Alpine tunnels. The schedule laid out for the work contemplates the completion of the first portion, giving a single-track rail communication between Brieg and Iselle, in a period of five years and nine months from the commencement of the work. The rate of progress up to the middle of 1900 was very satisfactory in this respect, having been kept fully up to the pace necessary for the completion of the tunnel by the middle of the year 1904.

An interesting feature of the work is the high temperature encountered in the mass of the mountains. A steady rise was experienced on both sides of the Alps, the thermometer rising from 16.4° C. at 900 metres penetration on the Swiss side, to 20.4°C, at a penetration of 2,000 metres, while at the same penetration on the Italian side the thermometer reached 28.4° C., or more than 83° F. Under such conditions the value of the auxiliary tunnel 10r the delivery of cool, fresh air directly at the headings is great, and without such a system the time for the completion of the tunnel would have been greatly prolonged by reason of the unexpectedly high temperatures encountered.

With the completion of the Simplon tunnel, direct rail communication will be effected through from Geneva to Milan. The distance between Calais and Milan, which is 1,095 kilometres by the Mont Cenis route, and 1,070 kilometres by way of the St. Gothard, will not be more than 942 kilometres by the Simplon. The Ostend-Simplon-Milan route will be 95 kilometres shorter than the Ostend-Gothard Milan route.

Improvements in Testing Materials.

SOME time ago we referred in these columns to the method, proposed by M. Ch. Frémont, for examining the resistance of materials of construction, notably iron and steel, by studying the deformations of lines inscribed upon the surface of the material before subjection to stress.

M. Frémont has made this method the subject of an elaborate paper presented befor the Congress for Testing Materials recently held at Paris, and from a publication of this paper in a recent issue of the *Revue de Mecanique* some abstracts are here made.

In practical work there are three elements of the strength of a material concerning which information is desired. 1, the limit of elasticity, beyond which the deformity of the test piece remains set; 2, the ultimate resistance of the specimen; 3, the total elongation of the test piece up to the moment of rupture. Of these the elastic limit is not always readily determined with percision, even upon testing machines provided with recording apparatus. Annealed steel or iron will give a well-defined limit when the same material, when hammered or drawn, furnishes curves upon which the desired point can only be arbitrarily selected. M. Frémont gives a number of examples of tests made upon pieces of the same material using different machines, the results showing clearly the variations which are experienced. The cost of such methods of test, involving, as they do, elaborate and expensive machines, the expenditure of much time in the preparation of specimens and conduct of tests, and delay in obtaining

results, led M. Frémont to devise a simpler method, concerning which he gives much interesting information in his paper.

After a careful consideration of the matter M. Frémont decided to adopt the bending test as revealing at the same time the effects of tensile and compression stresses, as at the same time being one readily and conveniently applied, using for this purpose a simple form of punching press.

As already indicated, the method of M. Frémont includes the tracing upon each side of the test piece of fine parallel lines, spaced one millimetre apart, and he has devised a simple and convenient apparatus for the preparation of the specimens. The test pieces themselves are much smaller than is necessary with the usual methods, the standard piece for the Frémont process being only 25 millimetres long, and 10 by 8 millimetres in cross section. The small size of the test piece renders it possible to take many specimens from various parts of a given sample of material, and in many cases the fragments produced in the working of an object will furnish pieces available for test. The machine in which these pieces are tested is made with a simple recording device, the force being measured by the elasticity of the machine itself, each machine being calibrated independently. From the diagram produced by the machine the actual strength of the specimen is found, while from an inspection of the lines under the microscope the important data concerning the manner of yielding are seen. In addition to the application of the stress by the direct bending action of the press, M. Frémont has extended his method to include drop tests, the general principle being the same. The drop tests, (being intended to produce rupture, are made upon test pieces which are nicked in order to localise the rupture, a special form of caliper being made to insure uniformity in the depth of nicking and render the results uniformly comparable.

As a practical example of the method as applied in actual work, M. Frémont gives the detailed account of the tests of a rail, showing how the test pieces were cut to represent practically every portion of the rail section. A metallographic study of the same section was also made and the appearance of the etched section given to enable the comparison between the stress tests and the physical structure to be made.

For the details of the application of the method the reader must refer to the original paper, which in itself contains so much that is valuable and interesting as to demand the attention of the engineer in any case. The really important point brought out in the whole is the fact that a method of test to be practically useful must be simple enough to be readily applied, so that it may be used constantly upon work in the course of construction. In this way alone can sufficient information be had about the character of the material put into a structure to enable the engineer to proceed with confidence as to the actual strength of the whole structure. Isolated tests made in such a manner that the results are not available until after the work has been put upon the material, or until after the whole structure has been nearly completed, are of but small value for the especial case under consideration, and are often unavailable for subsequent use. What is really needed is some current and continuous guide for the engineer in charge so that he may not be obliged to feel his way in the dark, and for this purpose there appears to be nothing so well adapted as the method devised by M. Frémont.

REVIEW OF THE AMERICAN PRESS

The Development of the Steam Turbine.

AMONG the papers presented at the recent meeting of the American Society of Mechanical Engineers may be noted an exhaustive examination of the history, development, and present status of the steam turbine, this being prepared by Professor R. H. Thurston, past president of the society.

After calling attention to the fact that the two modern forms of steam turbine, the Parsons and the De Laval, are practically identical in principle respectively with the reaction wheel of Hero (120 B. C.), and the steam wheel of Branca (A. D. 1629), Professor Thurston proceeds to show the high theoretical efficiency of such machines.

"The steam turbine is, in essence, economical through its simplicity and the directness which distinguishes its method of themodynamic losses are due, as in other subject to small loss of mechanical efficiency through friction of journals, it having but a single pair of rubbing parts, bearings of small diameter, although of enormous speed of revolution, and it is entirely free from the great source of waste in the reciprocating engine, that internal variation of temperature of metal-surfaces which, ranging from the temperature of prime steam to that of the exhaust, nearly produces wastes amounting to from 10 per cent. to sometimes 50 and more of the heat, steam and fuel supplied. In the steam-turbine, the internal surfaces, while it is in steady motion, are, in all parts, at a constant temperature, and that is the temperature, practically, of the steam in contact with the element of surface. Its only thermal loss is by conduction and radiation, and that may be made very small. Its thermodynamic losses are due, as in other steam engines, to incomplete expansion within the wheel and discharge of the fluid with considerable energy of mechanical motion through malproportion, maladjustment or lack of adaptation of the speed of discharging orifice to the velocity of the expanding, rejected fluid in such manner as to reduce its velocity of rejection, into the air or the condenser, to a minimum."

The performance of the "Turbinia," fitted with engines of the Parsons type, at her trials in 1894, giving speeds of more than 32 knots, with steam consumptions under 20 pounds of steam per horse-power, called general attention to the possibilities of the steam turbine, and the "Viper," the successor of the "Turbinia," with its trial speed of 37 knots, or more than 43 miles per hour, has confirmed the correctness of the principles on which both boat and motive power were designed.

"Steam turbines of great size and power are likely soon to be produced for many purposes, now that their performance has been found so satisfactory, and especially for torpedo-boat work, and their construction on a large scale will enable the engineer promptly to settle many questions of interest which the earlier work on small machines could not fully solve. It would seem that, as with the gas engines, the larger the scale of operation, the simpler the problems of design and construction, and the easier the approximate of the real to the ideal in perfecting the system of energy conversion. Large turbines are comparatively low in speed of revolution, and it is considered that it would be entirely practicable to build an ocean steamer of large size, driven by turbines of 30,000 or 40,000 high pressure, or more if needed, at speeds of revolution as low as 400 per minute or lower, employing four shafts and eight screws, requiring minimum steam and fuel for their work, while economizing enormously in space and weight. There would be no vibration or noise annoying to passengers, and their simplicity of construction and freedom from the multitudinous bearings of the now usual construction of engine would give insurance against either

breakdown or minor troubles and delays from heated journals, leakages about the engine, or other annoyances and expenses inseparable from the reciprocating machine. Steam pressures can be adopted at the maximum practicable with the steam-boilers of contemporary practice, whatever the limit may be. That limit will thenceforward always be found at the boiler."

In discussing the general theory of the steam turbine, Professor Thurston shows that such machines operate according to the Rankine or Clausius cycle, and gives a complete analysis of the ideal case for such a cycle, there being no compression. He thus shows that the steam turbine corresponds in actual operation more closely to its ideal cycle than any other form of motor, and is in fact the steam engine of maximum simplicity and highest thermal efficiency.

The length of Professor Thurston's paper precludes further abstract except so far as to give the conclusions deduced from his exhaustive examination of the whole subject.

These conclusions are as follows:

1. The steam-turbine thermodynamically approximates in its real form more closely to the ideal than does any other type of heat-motor. Its cycle lacks only the introduction of the Carnot compression.

2. It is entirely free from that waste, which in the real steam engine of common type constitutes usually, if not invariably, the most important of its extra thermodynamic losses.

3. It is peculiarly well fitted for use with those very high steam pressures, as we now regard them, which must ultimately probably be resorted to by the engineer designing heat engines, in his endeavor to further improve the efficiency of that class of motors.

4. It is only limited in speed of rotation by the strength of its materials of construction.

5. It is especially suitable for use with superheated steam, it having no rubbing parts on which lubrication may be difficult in presence of superheated steam, and the limit to the superheat, so far as the motor is concerned, being only found at that point at which increased temperature of metal produces reduction of tenacity in objectionable amount. That limit, not as in earlier days of lubrication with animal oils, and still with other engines, is fixed with this machine at the boiler.

6. As to its operation, it is obvious that friction is peculiarly active for evil in this motor, and that small diameters of journal, freedom from contact of part with part, except as absolutely required by the construction, and minimizing fluid friction by superheating steam, and by securing as complete removal of the atmosphere, air of vapor from about the revolving wheel as practicable, must be carefully sought, in order that the mechanical efficiency of the machine shall be made a maximum.

7. The wastes of the steam-turbine are all extra thermodynamic; the loss due, the absence of adiabatic recompression excepted. They consist of (1) journal-friction, which is made a minimum by the use of a flooded bearing and a light ungent; (2) fluid friction between disk and leakage, steam, or suspended moisture in the jet, which may be made a minimum by superheating, and between the disk and its enclosing atmosphere of vapor, which may be minimized by the employment of a good condenser; (3) loss of heat and of steam by leakage, which may be reduced to a minimum by durable material, fine workmanship, and close fits; (4) waste by incomplete expansion, which may be reduced to a limit determined by the finance of the case, by the resultant increase of friction and of cost due the necessary enlargement of the turbine; and, finally (5), thermodynamic waste by failure to secure that complete adiabatic recompression of the fluid which is necessary to convert the Rankine-Clausius' cycle into that of Carnot. The latter is a peculiarly difficult matter with the steam-turbine, since it probably necessarily involves the employment of a separate vapor-compression pump of special character, and an amount of added work and cost which may introduce losses more than compensating its gains.

The Coaling of Warships at Sea.

ABOUT a year ago there was presented before the Society of Naval Architects and Marine Engineers a paper by Mr. Spencer Miller upon the subject of the

problem of coaling vessels at sea, this paper being followed by another by the same author in the pages of this magazine for February, 1900, giving a detailed account of the work of the writer in solving this important problem. We now have a further paper by the same engineer presented before the same society, giving an account of the more recent experience in the solution of the problem, with comments upon the system employed by various naval experts.

As described in Mr. Miller's paper, above referred to, the main element in the problem lies in the maintenance of a suitable tension upon the cableway connecting the collier and the warship, it being understood that the conditions of warfare render it undesirable for vessels to leave their posts to take coal, while it is impracticable for colliers to be brought alongside except in harbor. The device employed by Mr. Miller involves the towing by one vessel of the other, a conveying cableway extending between the two vessels for the transfer of the coal from the collier to the warship. The plunging and pitching of the vessels in the sea has always rendered schemes of this nature impracticable until the device of a slipping winding drum was introduced, this taking up the slack and meeting the increased tension in a very satisfactory manner with the varying positions of the vessels. In connection with the two lines of the cableway there was added a third line connected with a sea anchor to support the carriage when empty on its return to the collier, but it has since been proposed to replace this with a slipping-drum tension-engine.

The paper is mainly devoted to an account of the trials in coaling the U. S. S. "Massachusetts" at sea, under the inspection of a trial board of United States naval officers, the tests being such as were prescribed by the Navy Department, in order to determine whether or no the device should be accepted by the government:

"The apparatus had five trials. On the first day adjustments were made and 9 loads only were sent over. On the second day more adjustments were made, and a run of 38 loads in 38 minutes and 40 seconds was suddenly terminated through the lack of skill on the part of the operator, who allowed all the rope to be coiled on the forward drum. This slipped the clip on the end of the rope through the other drum, and the rope fell into the sea. No damage was done, no one hurt, and the only penalty of such an accident was an hour's delay in rigging up again. On the third day, in one hour the apparatus transferred about 22 tons, and the work would have been continued longer but for lack of sufficient crew to fill the bags.

"The Navy Department then ordered an endurance test of not less than four hours' duration, and a rough weather trial as well. Twenty men were added to the crew to fill the coal bags.

"Between the third and fourth trials some trifling alterations were made. The fourth trial lasted four hours. Seventy-five tons were handled in 3 hours and 43 minutes. The water was smooth, with a ground swell. In the fifth test—the rough-weather trial—80 trips were made in 80 minutes. The performance could have been continued for an indefinite time, but the board being satisfied there was no object in going further.

"In the rough-weather trial, one hour and a half was consumed in securing the tow line and setting up the apparatus.

"The boats steered at first head-on to the sea. The forecastle of the 'Massachusetts' was washed at every plunge, and no coal could have been delivered there even if desired. A little more than 20 tons were handled in an hour. The course was then changed, quartering on the sea, and the results were the same. Then the boats steered in the trough of the sea, and a rolling of 7 degrees did not affect the working. The speed was maintained at about 5 knots. The 'Massachusetts' burned 3½ tons of coal per hour during the trial."

The result of the trials was the acceptance of the apparatus by the government, and it is now proposed to make the device a feature of fleets cruising away from convenient coaling stations. A prominent Vice-Admiral of the Royal Navy, in discussing the device, suggested that if its operation could be carried on at a ten-knot speed, and forty tons per hour capacity, its use should become universal. It was also suggested that all the operating machinery should be placed on the warship.

so that coal might be taken from any collier. The recommendations are entirely practicable, and there is no good reason why they may not be carried out. The importance of the subject of coaling at sea can hardly be overrated. Coal is the real essential of modern naval warfare, and no fleet can carry on operations for a prolonged time away from coaling stations without some satisfactory means of carrying coal to the enemy's coast and transferring the fuel from the colliers to the warships at any point and under any reasonable weather conditions.

A modern fleet accompanied by an auxiliary fleet of colliers and equipped with cableways for transfer of coal at sea is in a position to act, in fact, as if the first line of home defence was the enemy's coast, while without such apparatus this position would be untenable.

The introduction of modern mechanical devices in this fundamental element of naval warfare is another example of the manner in which the civilian engineer meets and solves problems which have confronted the naval engineer for long years, and shows the truth of the idea that the greatest improvements in any profession often come from those outside of its assumed limits.

Rebuilding the Kinzua Viaduct.

NEARLY twenty years ago the Kinzua viaduct, on the Erie Railroad, was considered one of the characteristic examples of American engineering construction, and its bold design and effective execution attracted much attention on both sides of the Atlantic. Notwithstanding the fact that the old viaduct remained in good condition up to the present time, the increase in the weight of locomotives and rolling stock rendered it advisable to provide additional strength, so that the whole structure has been entirely rebuilt, according to modern practice. The work was done by the Elmira Bridge Company, from the designs of Mr. C. R. Grimm, who describes the new structure very fully in a paper presented before the American Society of Civil Engineers.

The viaduct spans a deep valley, and is 2,053 feet long, the railway being carried on twenty towers varying in height from 30 feet to 285 feet, and in the old structure these towers were light as to the main members, and well counterbraced to resist lateral wind stresses.

In preparing the plans for the new design, Mr. Grimm decided to dispense with any secondary bracing, by building the wind bracing strong enough to take care of itself. The tower legs, being the real supporters of the railway, he also increased in dimensions, so that they stand out boldly, instead of looking rather slender and more or less overshadowed by a mass of bracings. This construction involved a considerable increase in the height of the stories, fewer members to build, a quicker erection, and a great reduction in field riveting. As shown in the drawings and photographs accompanying Mr. Grimm's paper, the towers are made of lattice members, both as to uprights and diagonals, except the top, which is composed of solid plates. The notable thing about these new towers is the height of the stories, this taken transversely being 62 feet, an increase of about 100 per cent. over that which is common in viaducts, while the height on the longitudinal faces is 31 feet. The dimensions, sizes, and details of all the towers are the same from their tops downward, or in other words, the dimensions, sizes, etc., for any tower are obtained from the tallest tower by shortening the same from the bottom upward.

Mr. Grimm goes quite fully into the analytical computations by which the towers were proportioned, this portion of his paper forming a valuable contribution to the study of wind stresses and their practical analysis for such framed structures. This is the more valuable since the stresses in frames of this kind have not before been analytically discussed, and hence the completeness of the study should be most acceptable to bridge engineers.

The work of erection of the viaduct was carried on simultaneously from each end by two travelers. These carried the hoisting machinery and spanned a clear space of 160 feet, having an old tower in the middle. In this position the old tower was taken apart, its material hoisted up and loaded on cars and run out to the shore end of the structure, and a new tower assembled. The work of removing the old viaduct and erecting the new one consumed four

months, with a force of about 120 men at 10 hours a day.

Apart from the direct interest in the work as a notable piece of bridge engineering, this construction of the Kinzua viaduct is a good example of the manner in which structures otherwise excellent become obsolete in a period far within their natural life. The old viaduct might, with reasonable care, have lasted many years longer, but it had to be scrapped and replaced by an entirely new structure, not for any defect of its own, but simply because the increased service demanded a heavier bridge. Whether it is better to follow this policy of replacement rather than to attempt to build for many generations ahead, may be a matter for discussion, but in many cases there is no choice.

The Experimental Basin at Washington.

EVER since the classical researches of Froude it has been realized by engineers and naval architects that the only way to ascertain accurately the behavior of proposed designs for vessels is by the use of models in the trial tank. Such tanks have been constructed by several private establishments, the most recent among them being the new one recently built by the Vulcan shipbuilding works at Stettin, but the most complete government tank is that of the United States at the Washington Navy Yard. This basin was fully described more than a year ago, at the time of its completion, by its designer, Naval Constructor D. W. Taylor, U. S. N., and reviewed in these columns at that time, and now we have from the same able pen an account of the experience had with it in actual service, this paper being presented at the recent convention of the Society of Naval Architects and Marine Engineers.

In view of the fact that a large sum is to be expended for the construction of additional vessels for the United States Navy, the importance of the possession of this testing basin cannot be over-estimated, and some brief description of it is desirable, supplementing the account given in these columns in the issue for August, 1899. There are two noteworthy features about the basin, one being its large size; length, 470 feet; width, 42 feet 8 inches; main section, 14 feet 8 inches deep; the other being that with the tank, models of 20 feet in length are tested, instead of the 12 foot size customary in the European basins. It is worthy of note that in the Washington tank wooden models are used, instead of those of paraffine, and in Mr. Taylor's paper the ingenious machinery for shaping the models is described at length.

The models are drawn through the tank by a traveling bridge, spanning the basin and operated by electric power, and upon the bridge is placed the recording apparatus for measuring the resistance and other data to be determined. The copious illustrations and elaborate working drawings accompanying Mr. Taylor's paper enable all questions as to construction and operation of the basin to be fully answered, and to them the interested reader is referred. At the present time the especial subject of interest is the account of the trials which have already been made, particularly with models of vessels already in service, the actual performance of which is well known.

In testing models of men-of-war, it is the usual practice at Washington to determine five resistance curves, each extending somewhat beyond the speed corresponding to the maximum speed of the vessel. These curves are made (1) at normal displacement, (2) with trim changed 4 inches by the head, (3) with trim changed 4 inches by the stern, (4) with displacement 10 per cent. lighter than normal, and (5) with displacement 10 per cent. heavier than normal.

As an example of the results obtained by such a series of tests, the curves for the U. S. S. "Yorktown" are given, and with these are also given the curves showing the actual changes in bow and stern levels of the model of the "Yorktown" at normal displacement. The peculiar characteristics of these curves are naturally best obtained by inspection, but may briefly be described here. Whenever the model is under way there is a tendency to settle, both bow and stern settling alike at low speeds, while as the speed increases the bow first settles and then begins to rise again. If the speed is pushed the bow rises even above its original level, the stern at the same time developing a tendency to sink. This settling does not imply a greater immersion in the water, as the

water level around the model is disturbed by its passage.

The speed curves of the "Yorktown" are given by themselves, and are also included in a general series of typical curves based upon experiments made with a number of models. All these show in general the same characteristics. At the portion of the curves between the speed of four and five knots for the models, corresponding to speeds of 16 to 20 knots for the full-sized vessels, certain peculiar humps form in the curves, these being most pronounced in the curves obtained from narrow, deep models, while they die away and appear only as flat spots for broad, shallow models. These humps are due to the interference between the bow and stern wave systems. For a fine model of low displacement, such as a model of a destroyer, this hump almost disappears, while for a battleship model the hump is very pronounced between four and five knots, the resistance curve becoming very steep after the 4 knot speed is passed.

The value of the trial basin is especially seen in the investigation of the tentative models made for the five vessels of the Georgia class, these being the most powerful battleships and the largest vessels yet undertaken by the United States government. The results obtained with these models show conclusively the direct practical value of model experiments. Taking two models for these vessels, the curves for which are given, it is shown that an increase of length, giving nearly 4 per cent. greater displacement, enables the desired speed of 19 knots to be obtained with 2,000 less horse power—19,000 h. p., as against 21,000 h. p.!

The use of the trial tank, which cost about $100,000, will enable the complete and satisfactory determination of such vital features as form, length, and powering for the five new battleships now under design, and which are estimated to cost some thirty millions of dollars, and for this single purpose alone, the value of the investment is apparent. The basin is also available for the testing of private models whenever it can be so employed without interfering with government work, and hence will doubtless be a great benefit to shipbuilders generally.

It is a matter of especial interest to note the freedom with which a government officer is permitted, as in this paper, to give to the world information and data which in other countries would be scrupulously guarded as state secrets, a policy which many will contrast with the secretive practice of nearly every other government in the world.

The Water-Jet in Engineering Construction.

ALTHOUGH the water-jet is an old device in connection with engineering work there appears nowhere so complete an account of its use as is found in a recent paper presented before the Engineers' Club of Philadelphia by Mr. L. Y. Schermerhorn.

"The general action of the water-jet may be illustrated by its operation in sinking ordinary wooden piles. The pile, properly held in position in the leaders of a pile-driver, is lowered upon the bottom, and the water-jet placed in operation close to the lower end of the pile; whereupon the pile, either through its own weight or aided by that of the pile hammer, lowered upon the head of the pile, rapidly sinks, with the water-jet, into the semi-fluid mass of sand which the water-jet has produced. All variations in the use of the water-jet for sinking piles are modifications of the action just described."

According to Mr. Schermerhorn, the earliest use of this method was made at Decrow's Point, Matagorda Bay, Texas, being suggested by Captain George B. McClellan, at that time chief engineer of the Department of Texas. A list of many important applications since that time in all parts of the world is given, with many details of the success which attended its use under difficult conditions.

Under certain circumstances, however, difficulties are encountered.

The experiments undertaken in connection with the work upon the improvement of the Mississippi and Missouri rivers showed that the water-jet cannot be relied upon to give satisfactory results in material containing a large percentage of gravel; that it should be capable of such concentration of its force as will permit the stream to be delivered through a nozzle not more than 1½ inches in diameter, and frequently somewhat less, and with pump power capable of giving a nozzle pressure of from 75

to 150 pounds per square inch, while the presence of gravel required the smaller nozzle and higher pressure.

"Various suggestions and experiments have been made relative to securing the action of the water-jet on a line coincident with the vertical axis of the pile, and while such efforts have been ingenious, experience has demonstrated that they did not secure greater efficiency than that obtained by placing the jet alongside of the pile in the manner previously described."

From the very nature of the jet it is evident that its action depends upon the high velocity and pressure of the stream of water, and this again is dependent upon the power and capacity of the pumps. Mr. Schermerhorn points out that it is a very common error to provide pumps of insufficient capacity, and in nearly every application in the early history of the process the efficiency would have been largely increased if the pumps and hose had been of much greater capacity. The tremendous power of the jets used in California in hydraulic mining is evidence of the effectiveness of such a method of penetrating material, and if such jets were intelligently applied to engineering work a like efficiency could doubtless be secured.

The hydraulic jet has been effectively used for grading on the Mississippi and Missouri rivers, and under favorable conditions in this work 6,000 cubic yards of material have been handled in a day of twelve hours. In this case material which cost from 10 to 12 cents a cubic yard when removed by shovels and scrapers, was handled by the jet at a cost of from 1.1 to 1.2 cents per yard.

The paper will doubtless call attention to a powerful method which has hardly been employed to the extent legitimately possible.

The Electric Measurement of Power.

At the recent convention of the American Society of Mechanical Engineers an interesting paper was presented by Professor Forrest R. Jones upon the subject of power and light for the machine shop and foundry. In discussing the selection of motors for driving various machine tools, the paper describes some measurements which show conclusively how useful the electrical method of measurement may be made, and incidentally gives some useful information as to the amount of power required for various mechanical operations. The tools investigated included lathes and similar tools, planers, involving a reciprocating motion with a reversal of nearly every part of the machines, electric hoists and cranes. and many minor tools. The power required by various tools naturally varied with the nature of the work, and the tests were made as a rule to determine the maximum, in order that sufficient motor capacity might be provided. At the same time it was made apparent that other considerations besides the useful work performed in many cases affected the power consumed, and showed the fallacy of measuring the power consumed by a tool by the amount of metal removed from the piece under the tool. In the case of lathes the tests were made upon them when polishing cylindrical pieces, the polishing laps gripping the work tightly, almost after the manner of a brake. Under these conditions the power required to drive two lathes, one of 48 and the other 36 inch swing, was a little over seven horse power.

In the case of a planing machine it was demonstrated that the greatest amount of power was required, not under the forward cutting motion, but during the return stroke, the maximum being indicated at the moment of reversal. In the case of a 120 inch planer, with 22 foot table, it was shown that the amount of power required for reversing was about 1.8 times that necessary for its average running at a time when not reversing. When this machine and another one 72 inches by 25 feet were both reversing at the same time, the power required at the moment of reversal ran up to 60 horse power. A similar action was exhibited by several planers, the greatest amount of power being required at the time of reversal from cutting to return stroke, this being doubtless due to the increase of speed at that time.

Tests of traveling cranes showed naturally a great variation in the demand for power under different conditions. As might be expected, the greatest amount of power was demanded during general manœuvring, when two or more functions were started at the same time. A 30 ton traveling crane, manœuvring with a 20 ton load, demanded

60 to 100 h. p., while hoisting 20 tons uniformly at 10 feet per minute required about 33 h. p. of electrical energy. As this latter operation corresponds to only about 12 h. p. of work, the mechanical efficiency of this particular machine appears to have been about 36 per cent.

Another revelation made by the electric testing of power consumption was that of an elevator, ordinarily driven mechanically from the line shaft by means of worm and worm-wheel connected to the elevator winding drum. Ordinarily this elevator should not have required more than 5 horse power to operate it, whereas it actually required from 2.5 up to nearly 22 horse power in going up without load, and 10 to 0.1 horse power in going down. Although the worm gearing appeared to be all right and was well lubricated, this great variation in power evidently pointed to defective adjustment.

These and various other measurements, although primarily intended to be used for the determination of the proper motors for use in installing electric power in a given establishment, afford an instructive lesson in the usefulness of the electrical method of measuring power. When machine tools are driven by independent motors, a glance at the volt and ampere meters will enable the fluctuations to be read off. This advantage, apart from the general superiority of electric driving, is well worth noting, and with the general introduction of electric power, will contribute much to our knowledge of the utilization and waste of power.

Relations Between Engine and Generator Builders.

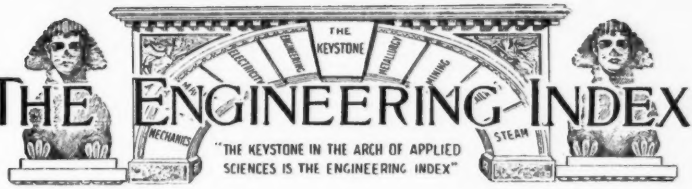
ONE of the conspicuous features of the power section of the Paris Exposition was the almost universal practice of combining steam engines and electric generators into sets, the generator being either direct-connected to the engine shaft or forming an integral structure with the fly-wheel. This practice is also becoming so common in the United States that it formed the main portion of the discussion at the recent meeting of the Engine-Builders' Association, papers being presented by both builders of engines and generators.

Although in some cases the generating sets, as they are now commonly called, are built entirely by one establishment, yet in the majority of instances the engines and electrical work are the products of different shops. If the benefits of standardization are to be obtained it is therefore necessary that there should be some general uniformity of practice, not necessarily in details of design or construction, but in proportion and dimensions of parts common to both portions of the combined structure, so that the customer may be able to choose the engine and the generator and yet permit open competition.

The main things to be considered are that the engine and generator should be analagous so far as capacity, speed, and regulation are concerned. Electric generators are designed to permit of a decided overload for a brief period, experience having shown the great advantage of this, but this overload capacity avails nothing if the steam portion of the set is not equally proportioned.

When generators are to be run in multiple the governing of the engines is an important matter and should be considered with respect to its peculiar service. The absolute uniformity of speed is not so important as the limit of angular variation. Steam engines intended for directly connected dynamos should not have an angular deviation in degrees of more than 2½ or 3 degrees of phase. In order to obtain this result it is necessary so to proportion the fly-wheel, relative to the weight of the other moving parts, as to make sure that the limit of angular variation is not exceeded, and this cannot be done unless the engine maker and the generator builder act in harmony.

The whole subject of the standardization of direct-connected sets is under consideration by a joint committee of the American Society of Mechanical Engineers and the American Institute of Electrical Engineers, and now that the matter has also been taken up by the Engine-Builders' Association there is every reason to believe that satisfactory standard proportions in essentials will be secured without hindering the progress of invention and improvement in both branches.



THE ENGINEERING INDEX

The object of this Index is to supply all persons interested in engineering and industrial pursuits with, first, an expert descriptive summary clearly indicating the character and purpose of the leading articles published currently in the established technical journals of the United States, Great Britain, and the Continent—in all languages; and, secondly, an inexpensive means of readily obtaining any portions of this literature that may be desired by our readers.

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THE PUBLICATIONS REGULARLY REVIEWED AND INDEXED.

The titles and addresses of the journals regularly reviewed are given here in full, but only abbreviated titles are used in the Index. In the list below, *w* indicates a weekly publication, *b-w*, a bi-weekly, *s-w*, a semi-weekly, *m*, a monthly, *b-m*, a bi-monthly, *qr*, a quarterly, *s-q*, semi-quarterly, etc. Other abbreviations used in the index are: Ill—Illustrated; W—Words; Anon—Anonymous.

American Architect. *w.* Boston, U. S. A.
American Electrician. *m.* New York.
Am. Engineer and Railroad Journal. *m.* New York.
American Gas Light Journal. *w.* New York.
American Geologist. *m.* Minneapolis, U. S. A.
American Jl. of Science. *m.* New Haven, U. S. A.
American Machinist. *w.* New York.
Am. Manufacturer and Iron World. w. Pittsburg, U. S. A.
American Shipbuilder. *w.* New York.
Annales des Pontes et Chaussées. *m.* Paris.
Architect. *w.* London.
Architectural Record. *qr.* New York.
Architectural Review. *s-q.* Boston, U. S. A.
Architect's and Builder's Magazine. *m.* New York.
Australian Mining Standard. *w.* Sydney.
Automobile Magazine. *m.* New York.
Automotor & Horseless Vehicle Jl. *m.* London.
Brick Builder. *m.* Boston, U. S. A.
British Architect. *w.* London.
Brit. Columbia Mining Rec. *m.* Victoria, B. C.
Builder. *w.* London.
Bulletin Am. Iron and Steel Asso. *w.* Philadelphia, U. S. A.
Bulletin de la Société d'Encouragement. *m.* Paris.
Bulletin of Dept. of Labor. *b-m.* Washington.
Bulletin of the Univ. of Wisconsin, Madison, U. S. A.
Bull. Int. Railway Congress. *m.* Brussels.
California Architect. *m.* San Francisco, U. S. A.
Canadian Architect. *m.* Toronto.

Canadian Electrical News. *m.* Toronto.
Canadian Engineer. *m.* Montreal.
Canadian Mining Review. *m.* Ottawa.
Chem. Met. Soc. of S. Africa. *m.* Johannesburg.
Colliery Guardian. *w.* London.
Compressed Air. *m.* New York.
Comptes Rendus de l'Acad. des Sciences. *w.* Paris.
Consular Reports. *m.* Washington.
Contemporary Review. *m.* London.
Deutsche Bauzeitung. *b-w.* Berlin.
Domestic Engineering. *m.* Chicago.
Eclairage Electrique. *w.* Paris.
Electrical Engineer. *w.* London.
Electrical Review. *w.* London.
Electrical Review. *w.* New York.
Electrical World and Engineer. *w.* New York.
Electrician. *w.* London.
Electricien. *w.* Paris.
Electricity. *w.* London.
Electricity. *w.* New York.
Elektrizität. *b-w.* Leipzig.
Elektrochemische Zeitschrift. *m.* Berlin.
Elektrotechnische Zeitschrift. *w.* Berlin.
Elettricita. *w.* Milan.
Engineer. *w.* London.
Engineer. *s-m.* Cleveland, U. S. A.
Engineers' Gazette. *m.* London.
Engineering. *w.* London.
Engineering and Mining Journal. *w.* New York.
Engineering Magazine. *m.* New York & London.
Engineering News. *w.* New York.
Engineering Record. *w.* New York.
Eng. Soc. of Western Penn'a. *m.* Pittsburg, U. S. A.
Fire and Water. *w.* New York.
Foundry. *m.* Detroit.
Gas Engineers' Mag. *m.* Birmingham.
Gas World. *w.* London.
Génie Civil. *w.* Paris.
Gesundheits-Ingenieur. *s-m.* München.
Giorn. Dei Lav. Pubb. e d. Str. Ferr. *w.* Rome.
Glaser's Ann. f. Gewerbe & Bauwesen. *s-m.* Berlin.
Horseless Age. *m.* New York.
Ice and Refrigeration. *m.* New York.
Indian and Eastern Engineer. *m.* Calcutta.
Iron Age. *w.* New York.
Iron and Coal Trades Review. *w.* London.
Iron & Steel Trades Journal. *w.* London.
Iron Trade Review. *w.* Cleveland.
Journal Assn. Eng. Societies. *m.* Philadelphia, U. S. A.
Journal of Electricity. *m.* San Francisco.
Journal Franklin Institute. *m.* Philadelphia.
Journal of Gas Lighting. *w.* London.
Journal Royal Inst. of Brit. Arch. *s-qr.* London.
Journal of Sanitary Institute. *qr.* London.
Journal of the Society of Arts. *w.* London.
Journal of U. S. Artillery. *b-m.* Fort Monroe, U. S. A.
Journal Western Soc. of Eng. *b-m.* Chicago.
Journal of Worcester Poly. Inst., Worcester, Mass.
L'Energie Electrique. *w.* Paris.
Locomotive. *m.* Hartford, U. S. A.
Locomotive Engineering. *m.* New York.
Machinery. *m.* London.
Machinery. *m.* New York.
Marine Engineering. *m.* New York.
Marine Review. *w.* Cleveland, U. S. A.
Metal Worker. *w.* New York.
Mem. de la Soc. des Ing. Civils de France. *m.* Paris.
Mines and Minerals. *m.* Scranton, U. S. A.
Mining and Sci. Press. *w.* San Francisco, U. S. A.
Mining Reporter. *w.* Denver, U. S. A.
Mitt. aus d Kgl. Tech. Versuchsanst. Berlin.
Mittheilungen des Vereines für die Förderung des Local und Strassenbahnwesens. *m.* Vienna.
Modern Machinery. *m.* Chicago.
Moniteur des Architects. *m.* Paris.
Moniteur Industriel. *w.* Paris.
Municipal Engineering. *m.* Indianapolis, U. S. A.
National Builder. *m.* Chicago.
Nature. *w.* London.
Nature. *w.* Paris.
Nautical Gazette. *w.* New York.
New Zealand Mines Record. *m.* Wellington.
Nineteenth Century. *m.* London.
North American Review. *m.* New York.
Oest. Monatsschr. f. d. Oeff. Baudienst. *m.* Vienna.
Oest. Zeitschr. f. Berg- & Hüttenwesen. *w.* Vienna.
Ores and Metals. *w.* Denver, U. S. A.
Plumber and Decorator. *m.* London.
Popular Science Monthly. *m.* New York.
Power. *m.* New York.
Practical Engineer. *w.* London.
Pro. Am. Soc. Civil Engineers. *m.* New York.
Proceedings Engineers' Club. *qr.* Philadelphia, U. S. A.
Proceedings St. Louis R'way Club, *m.* St. Louis, U. S. A.
Progressive Age. *s-m.* New York.
Railroad Car Journal. *m.* New York.
Railroad Gazette. *w.* New York.
Railway Age. *w.* Chicago.
Railway & Engineering Review. *w.* Chicago.
Review of Reviews. *m.* London & New York.
Revue de Mécanique. *m.* Paris.
Revue Gen. des Chemins de Fer. *m.* Paris.
Revue Technique. *b-m.* Paris.
Revue Universelle des Mines. *m.* Liége.
Rivista Marittima. *m.* Rome.
Sanitary Plumber. *s-m.* New York.
Schweizerische Bauzeitung. *w.* Zürich.
Scientific American. *w.* New York.
Scientific Am. Supplement. *w.* New York.
Stahl und Eisen. *s-m.* Düsseldorf.
Stevens' Institute Indicator. *qr.* Hoboken, U. S. A.
Stone. *m.* New York.
Street Railway Journal. *m.* New York.
Street Railway Review. *m.* Chicago.
Telephone Magazine. *m.* Chicago.
Tramway & Railway World. *m.* London.
Trans. Am. Ins. Electrical Eng. *m.* New York.
Trans. Am. Ins. of Mining Eng. New York.
Trans. Am. Soc. of Civil Eng. *m.* New York.
Trans. Am. Soc. of Heat & Ven. Eng. New York.
Trans. Am. Soc. Mech. Engineers. New York.
Trans. Inst. of Engrs. & Shipbuilders in Scotland, Glasgow.
Transport. *w.* London.
Western Electrician *w.* Chicago.
Wiener Bauindustrie Zeitung. *w.* Vienna.
Yacht. *w.* Paris.
Zeitschr. d. Oest. Ing. u. Arch. Ver. *w.* Vienna.
Zeitschr. d. Ver. Deutscher Ing. *w.* Berlin.
Zeitschrift für Elektrochemie. *w.* Halle a. S.
Zeitschrift für Elektrotechnik. *s-m.* Halle a. S.

ARCHITECTURAL ENGINEERING

CONSTRUCTION.

Building Details.

The Gill Building, New York. Illustrated description of the foundations and steel work in a 15-story, 56 x 86-ft. building. A number of the connections in the metal work are of special design. 2500 w. Eng Rec—Nov. 3, 1900. No. 37509.

Building Support.

A Novel Method of Supporting a Building Over a Running Stream. Illustrated description of the solution of a troublesome problem in construction, in connection with extensions of the plant of the N. Y. Rubber Co., at Matteawan, N. Y. 800 w. Eng News—Nov. 15, 1900. No. 37680.

Changes.

Structural Changes in the Hotel Iroquois. Illustrates and describes the method of adding three stories of steel-cage construction on the top of the old walls of a Buffalo building. 450 w. Eng Rec—Nov. 24, 1900. No. 37930.

Cold Storage.

A Modern Small Cold Storage House. Eugene T. Skinkle. Discusses what is the best material for construction, how to build, piping, etc. Ill. 1600 w. Ice & Refrig—Nov., 1900. No. 37514 C.

Color Treatment.

The Color Treatment of the Pan-American Exposition. Edward Hale Brush. An account of the plans to carry out the color scheme with success. 1800 w. Sci Am—Nov. 10, 1900. No. 37557.

Exposition.

The Festival Hall of the Exposition (La Salle des Fêtes de l'Exposition). G. Bähr. A very complete account of the structural work of the building constructed within the old Machinery Hall of the Exposition of 1889 for the ceremonial events of the Exposition of 1900. 3000 w. 1 plate. Génie Civil—Nov. 3, 1900. No. 37802 D.

Foundations.

Reconstructing the Defective Foundations of the Hotel Wollaton, Brookline, Mass. A description of the defective foundation and its probable cause, and of the proposed method of repairing it. 1300 w. Eng News—Nov. 15, 1900. No. 37681.

The Puenmatic Caisson Foundations for the Broad-Exchange Building, New York City. An illustrated description of the apparatus and methods of work in constructing the foundations of what will be the largest office-building in the United States. 2500 w. Eng News—Nov. 15, 1900. No. 37689.

Office Building.

The Broadway-Chambers. Illustrated description of a fine 18-story building in New York, which was fully represented at the Paris Exhibition. 1200 w. Arch & Builds' Mag—Nov., 1900. No. 37577 C.

Tenements.

Tenement Houses. Edward T. Potter. Answer to a circular letter of inquiry concerning the design and construction desirable. 7500 w. Am Archt—Nov. 24, 1900. No. 37914.

HEATING AND VENTILATION.

Drying.

A Modern Steam Dry Floor. C. M. Hurt. Illustrated description of the construction and regulation of floors for drying clay workers' wares, and a statement of their advantages. 2500 w. Brick—Nov. 1, 1900. No. 37521.

Heating System.

A Residence Heated by a Furnace. Illustrates and describes a hot-air furnace which satisfactorily heats 18 rooms. 1900 w. Met Work—Nov. 10, 1900. No. 37576.

Hygrometer.

Use of the Hygrometer in Studies of Ventilation. A review of a paper by J. H. Kinealy. 2300 w. Jour Gas Lgt—Nov. 20, 1900. No. 37938 A.

Schools.

A Typical Chicago School Heating and Ventilating Plant. Illustrated detailed description of the system used. 2800 w. Eng Rec—Nov. 24, 1900. No. 37932.

Heating and Ventilating in a Small Schoolhouse. Illustrated description of the system in a 12-room building, using direct steam radiation. 1500 w. Eng Rec—Nov. 10, 1900. No. 37587.

PLUMBING AND GAS FITTING.

Drainage.

The Drainage of a House. William Paul Gerhard. Discusses progress made in house sanitation; the essential points of sanitary plumbing; the construction and fundamental requirements. 3500 w. Dom Engng—Nov. 15, 1900. No. 37721 C.

Gymnasium.

A New York Public Bath and Gym-

nasium. Illustrated description of a recreation building in a tenement house district in New York. 600 w. Eng Rec —Nov. 10, 1900. No. 37586.

Materials.

Improvements in Plumbing Materials. David Whiteford. Comments on recent changes, and plumbing developments. 1800 w. Dom Engng—Nov. 15, 1900. No. 37722 C.

Swimming Bath.

A Racquet Club Swimming Bath. Illustrated description of the details of a 15 x 22-ft. plunge bath with special features of waterproofing at the sides and bottom. 700 w. Eng Rec—Nov. 3, 1900. No. 37511.

MISCELLANY.

Estimating.

Estimating. Fred. T. Hodgson. Presents the simplest possible methods of obtaining quantities required in estimating materials. 2200 w. Archts' & Builds' Mag—Nov., 1900. Serial. 1st part. No. 37578 C.

Exposition.

The Pan-American Exposition at Buffalo, N. Y., in 1901. Brief illustrated description of the plans and scope of this exposition, with statement of the progress made at the present time. 3000 w. Eng News—Nov. 8, 1900. No. 37600.

Hanging Bells.

Method of Hoisting a Set of Large Bells. E. J. Lennox. A description of method of hoisting the large bells to the tower of the new city buildings in Toronto, Can. Ill. 800 w. Can Archt—Nov., 1900. No. 37915 C.

Windows.

Diffusion of Light. Edward Atkinson. The present article reports experiments made and conclusions, and begins the discussion of the advantage of this principle in lighting factories, work shops, schoolrooms, etc. 4000 w. Am Archt—Nov. 10, 1900. Serial. 1st part. No. 37633.

CIVIL ENGINEERING

BRIDGES.

Cantilever.

Strengthening the Michigan Central R. R. Cantilever Bridge, Niagara Falls, N. Y. Illustrated description of the methods and details of the work. 2300 w. Eng News—Nov. 1, 1900. No. 37553.

Concrete Arch.

A Concrete Arch Railroad Bridge. Illustrated detailed description of a semicircular, single-barrel arch of 15-ft. radius, recently put in service at Sharpsville, Pa. 1500 w. R R Gaz—Nov. 16, 1900. No. 37669.

The Lamington Concrete Steel Bridge. Describes the interesting features of a low-level bridge in Queensland. 1200 w. Eng Rec—Nov. 17, 1900. No. 37777.

Construction.

Improvements in Bridge Construction. Report on the exhibit of the Pencoyd Iron Works, at the National Export Exposition, held in Philadelphia, Oct.-Nov., 1899. 1600 w. Jour Fr Inst—Nov., 1900. No. 37456 D.

Ferry-Bridge.

The Ferry-Bridge at Bizerta. Illustrated description. 800 w. Sci Am Sup —Nov. 3, 1900. No. 37428.

Girders.

Old Girders. A report of an engineer's experiences with these girders, showing them only fit for the scrap heap, and suggesting that a most careful examination be made of all such material that it is proposed to use again. Ill. 1600 w. Engr, Lond—Oct. 26, 1900. No. 37531 A.

The Development of the Fundamental Equations of a Girder (Entwickelung der Grundgleichungen eines Tragers). Prof. Ramisch. A mathematical development of a new theory for girders, with any given number of supports. 3500 w. Zeitschr d Oesterr Ing u Arch Ver—Oct. 19, 1900. No. 37815 B.

Removal.

An Interesting Bridge Removal. Illustrated description of method of moving a 375-ft. single track bridge nearly a mile. 400 w. Eng Rec—Nov. 3, 1900. No. 37506.

Specifications.

Proposed Specifications for Steel Railroad Bridges. J. W. Schaub. Gives proposed methods explaining why they are advocated, also specifications, and a general discussion. 20000 w. Jour W Soc of Engrs—Oct., 1900. No. 37417 D.

Suspension.

A Footway Suspension Bridge with Three Towers, at Easton, Pa. H. G. Tyrrell. Drawings, description, and extracts from specifications. 1100 w. Eng News—Nov. 22, 1900. No. 37922.

The New Chain Bridge at Budapest. Illustrated description of a suspension

bridge of 1,242 ft. total span, having chains of links machined from plates by means of special tools. 2400 w. Eng Rec—Nov. 10, 1900. No. 37581.

Swing Bridge.

The Neuhof Swing-Bridge Over the Reiherstieg at Hamburg-Neuhof (Die Drehbrucke Neuhof über den Reiherstieg bei Hamburg-Neuhof). C. Bernhard. A full account of the details of this peculiar example of swing-bridge construction, with strain diagrams and other illustrations. Two articles. 7500 w. Zeitschr d Ver Deutscher Ingenieure—Oct. 20, 27, 1900. No. 37812 each D.

Trusses.

The Development of Bridge Members. A discussion of the relative advantages of eye bars and built sections for tension chords. 1000 w. Eng Rec—Nov. 10, 1900. No. 37579.

The Development of Bridge Trusses. An editorial discussion of present tendencies in American bridge design. 800 w. Eng Rec—Nov. 3, 1900. No. 37502.

The Strength of End Joints in Wooden Trusses. F. E. Kidder. An analysis of the tests on truss joints made in the engineering laboratories of the Mass. Inst. of Tech. in 1897. Ill. 2200 w. Eng Rec—Nov. 17, 1900. No. 37776.

Viaduct.

The Grasshopper Creek Viaduct. Illustrated description of a viaduct 650 ft. long, with a maximum height of 88 ft. above the tops of the masonry pedestals of the tower posts. 1000 w. Eng Rec—Nov. 24, 1900. No. 37929.

Willis Avenue Bridge.

The Willis Avenue Bridge, New York. Illustrated detailed description of bridge across the Harlem River, which is 60 ft. wide and 2,507 ft. long. 2500 w. Eng Rec—Nov. 17, 1900. No. 37774.

CONSTRUCTION.

Foundations.

See Architectural Engineering, Construction.

Pile-Driving.

Notes on Pile-Driving. James C. Haugh. Discussion of experience in pile-driving by the writer and members. 3700 w. Jour Assn of Engng Socs. Sept., 1900. No. 37447 C.

Reinforced Concrete.

Monier Constructions. E. Lee Heidenreich. Gives the different formulæ used in the calculations, also papers and discussion of this subject containing matter of interest. Ill. 3500 w. Jour W Soc of Engs—Oct., 1900. No. 37415 D.

Roads.

American Road Builders in Porto Rico. Albert Wells Buel. Information concerning the work in progress, the difficulties, cost, etc. Ill. 1800 w. R R Gaz—Nov. 23, 1900. No. 37747.

Fallacies and Facts Concerning Good Roads. Editorial on a paper by I. O. Baker, printed in *The Technograph*, concerning misleading statistics that have been published. 2500 w. Eng News—Nov. 15, 1900. No. 37686.

Shell Roads in Maryland. Extract from the Maryland Geol. Survey's Report on the State Highways, relating to roads surfaced with oyster shells. 1300 w. Eng Rec—Nov. 17, 1900. No. 37780.

Subways.

The Elm Street Subways in New York. An account of the scheme to build galleries for pipes on each side of the rapid transit subway, and the cause of the work being discontinued. Ill. 1200 w. Eng Rec—Nov. 17, 1900. No. 37775.

Tunneling.

The Simplon Tunnel (Le Tunnel de Simplon). A. Dumas. A very full and illustrated account of the work on the Simplon tunnel as conducted up to date, with maps, profile, and numerous views. 3500 w. Génie Civil—Oct. 27, 1900. No. 37808 D.

HYDRAULIC AND MARINE.

Discharge of Water.

Diagram Giving Discharge of Pipes by Kutter's Formula. John H. Gregory. Illustrated description of a large diagram for determining the discharge, friction loss, the velocity and diameter of pipes 1,000 ft. long. The diagram is characterized by the good intersection of the various lines. 1300 w. Eng Rec—Nov. 3, 1900. No. 37505.

The Miners' Inch and the Discharge of Water Through Various Orifices Under Low Heads. Thos. Drummond. A record of water determinations made in the hydraulic laboratory of McGill Univ., Montreal, with explanation of the term "miners' inch." 3700 w. Can Soc of Civ Engs—Adv. Proof, Nov. 22, 1900. No. 37772 D.

Docks.

Manchester Dock Extension. An illustrated description of extensions made necessary by the increasing activity in traffic and circumstances connected. 1300 w. Builder—Oct. 27, 1900. No. 37540 A.

The New 750-ft. Dry-Dock of the San Francisco Dry-Dock Co., at Hunter's Point, Cal. Illustrated detailed description of a proposed addition to the dry-dock facilities of the Pacific Coast, its equipment, power plant, etc. 3000 w. Eng News—Oct. 25, 1900. No. 37550.

The Uraga Docks, Japan. Description, with illustrations, of a second set of docks

nearing completion. 1400 w. Engr, Lond —Nov. 2, 1900. No. 37619 A.

Dredging.

Modern Methods of Deep Sea Sounding and Dredging. Harry C. Martin. Brief description, with illustration of a sounding machine. 900 w. Yale Sci M—Nov., 1900. No. 37708 C.

New Dredger Built in Great Britain. Description of a trial trip of a new suction dredger, built on the Tyne on an American system. 1200 w. U. S. Cons Repts, No. 890—Nov. 19, 1900. No. 37703 D.

Filtration.

An Experimental Water Filtration Plant: Its Design, Use, Economy and Value. Floyd Davis. On the wisdom of experimental investigation before installing a system, and suggestions. 1000 w. Munic Engng—Nov., 1900. No. 37460 C.

Filtration for Moscow, Russia. Extract from article by M. Nicholas Simin, with brief review. 1200 w. Fire & Water—Nov. 3, 1900. No. 37570.

Specifications for a Mechanical Filter Plant. Extracts from specifications prepared for the Brooklyn water-works, giving the features of special interest. 1500 w. Eng Rec—Nov. 17, 1900. No. 37778.

The Benefit of Alum in Water Filtration. Charles V. Chapin, in the *Providence Medical Journal.* Report concerning the East Providence, R. I., filter, claiming there is no alum in the water after filtration, as shown by tests. 1800 w. San—Nov., 1900. No. 37498 D.

Water Filtration in Germany. E. Beer. Translation of parts of an address on the recent history of filtration in Germany, and the features which are yet to be settled. 3900 w. Eng Rec—Nov. 3, 1900. No. 37507.

Force Mains.

Wood-Stave Pipe for Force Mains. States the conditions at Atlantic City, N. J., which led to the recommendation of wood-stave pipe, with reasons for the choice. 1300 w. Eng Rec—Nov. 24, 1900. No. 37933.

Irrigation.

The Condition of Water and Power Development in Southern California. L. K Sherman. On the great necessity of irrigation in this region, the types of construction used in water power development, etc. 2000 w. Jour W Soc of Engs —Oct., 1900. No. 37416 D.

Jetties.

Jetty Construction at Bilbao and Zeebrugge. Description of works, interesting because greatly facilitated by the novel method of constructing the piers by means of iron caissons filled with concrete. Ill. 1200 w. Engr, Lond—Nov. 2, 1900. No. 37617 A.

Nicaragua Canal.

The Nicaragua Canal Bill in Congress. Editorial discussion of the probability of the U. S. Congress authorizing the construction of this canal, and of matters related to the project. 1800 w. Eng News—Nov. 29, 1900. No. 37935.

Pollution.

The Pollution of Public Water Supplies in the United States. Report of the committee of the American Public Health Assn., presented at the Indianapolis meeting. 6000 w. Munic Engng—Nov., 1900. No. 37462 C.

Pumping Costs.

Cost of Pumping Water. William C. Webber. Conclusions reached from recent investigations of municipal plants, with chart showing graphically the relation that the cost of pumping 1,000,000 gals. one foot high, has to different quantities to different heights. 300 w. Power—Nov., 1900. No. 37454.

Purification.

The Present Status of Methods of Purification of Water in America. A report to the American Public Health Assn., by Allen Hazen, giving statistics of large plants. 1800 w. Eng Rec—Nov. 10, 1900. No. 37584.

The Status of Foreign Methods of Water and Sewage Purification. A statement prepared for the American Public Health Assn. 700 w. Eng Rec—Nov. 10, 1900. No. 37583.

River Improvement.

Chinese Trade and Chinese River Improvement. William Starling. Discussing especially the regulation of the Yellow River as an artery of commerce. 4000 w. Engineering Magazine—Dec., 1900. No. 37862 B.

Hoogli River—Proposed Deep Water Approach to Calcutta. Lindon W. Bates. Describes the physical characteristics and discusses the remedial projects, giving the writer's proposals in detail. Plates. 13000 w. Jour W Soc of Engs—Oct., 1900. No. 37419 D.

The Débris Problem in the Sacramento Valley. Information from the Report of the California Débris Commission, concerning the prevention of injury to navigation in the Sacramento Valley from the enormous quantity of material washed into the river beds by hydraulic mining. 2500 w. Eng Rec—Nov. 24, 1900. No. 37931.

The Erosion of River Beds. Critical letter discussing the plan of improving the southwest pass of Mississippi as outlined by Lewis M. Haupt, with reply from the author. Ill. 3000 w. Eng News—Oct. 25, 1900. No. 37552.

The Canalisation of the Moldau and the Elbe in Bohemia (Die Canalisierung

des Moldau und Elbeflusses in Böhmen). H. Franz. Giving illustrations of the movable dams and details of the projected improvements. 2500 w. 1 plate. Oesterr Monatschr f d Oeffent Baudienst—Nov., 1900. No. 37847 D.

The Meeker Island Dams and Locks. James A. Gould. Information concerning work under construction which will give Minneapolis a commercial waterway. Ill. 1700 w. Yale Sci M—Nov., 1900. No. 37707 C.

Sedimentation.

Sedimentation Tanks, with Numerous Circular Overflow Weirs; Denver Union Water Co. Illustrated description. 1000 w. Eng News—Nov. 15, 1900. No. 37687.

Ship Canals.

Central American Ship Canals. Devoted mostly to the Panama enterprise, giving the history of its development. Map. 3500 w. Engr, Lond—Oct. 26, 1900. Serial. 1st part. No. 37530 A.

Tunis.

The Ports of Tunis (Les Ports Tunisiens). An account of the present condition of the harbours of Sfax and Tunis, and suggestions as to their improvement. 2000 w. Revue Technique—Oct. 25, 1900. No. 37810 D.

Turbidity.

A Comparative Study of Methods Used for the Measurement of the Turbidity of Water. George C. Whipple and Daniel D. Jackson. A study of methods with the view of determining a standard, with conclusions. 4400 w. Tech Quar—Sept., 1900. No. 37501 E.

Waste.

Detection of Waste in the Water Supply of Towns. An account of the method of detection used in Torquay. Ill. 1200 w. Engr, Lond—Nov. 16, 1900. No. 37798 A.

Water Famine.

The Recent Water Famine in Paris; Water Waste and Purification. Abstracted by Allen Hazen from an article in *Technologie Sanitaire,* written by Adolph Kemna. Discusses the evident waste of water, and many problems connected with the supply. With editorial. 3800 w. Eng News—Oct. 25, 1900. No. 37549.

Water Supply.

The Limited Water Supply of the Arid Region. Frederick H. Newell. Statements of conditions and facts concerning the probability of the development of these regions. 1500 w. Nat Geog Mag—Nov., 1900. No. 37499 C.

The Pollution of Public Water Supplies. Extracts from the report to the American Public Health Assn., summarizing the features of the situation in the United States in 1900. 3600 w. Eng Rec—Nov. 3, 1900. No. 37510.

The Water Supply Tunnels of Chicago. An illustrated detailed description of the entire system, giving also the history of the Chicago water supply. 7000 w. Eng News—Oct. 18, 1900. No. 37542.

Water Works.

Flood-Water Channel of the Altoona, Pa., Reservoirs. Charles W. Knight. Illustrated detailed description. 2000 w. Fire & Water—Nov. 3, 1900. No. 37569.

Wells.

The Wells of the Ottakring Brewery (Die Brunnen der Brauerei in Ottakring). Ph. Forchheimer. Describing the method adopted for sinking and lining wells to a depth of 279.7 metres (918 feet). 3000 w. Zeitschr d Oesterr Ing u Arch Ver—Nov. 9, 1900. No. 37846 B.

MATERIALS.

Cement.

Portland Cement—Sketch of Materials and Process. T. B. Newberry. General description of the Portland cement industry. 4300 w. Eng Rec—Nov. 10, 1900. No. 37580.

Concrete.

Tests of Concrete for Elastic Properties and Ultimate Strength. W. H. Henry. Gives results of tests and conclusions derived from them, and considers briefly some of the factors entering into the mixing and placing of concrete which affect its efficiency. 2800 w. Jour Assn of Engng Socs—Sept., 1900. No. 37448 C.

Impact.

An Apparatus for Experiments in Impact. W. K. Hunt and W. P. Turner. Extracts from a paper before the Paris International Congress for the Unification of Tests of Materials. Illustrated description of impact testing machines and their use. 1700 w. R R Gaz—Nov. 23, 1900. No. 37744.

MEASUREMENT.

Spirit Levels.

Spirit Levels on Engineer's Field Instruments. Harold Van Duzee. Discusses the reliability of the spirit levels attached to transits and levels. 4000 w. Eng News—Nov. 22, 1900. No. 37923.

MUNICIPAL.

Garbage.

How Properly to Collect and Dispose of Garbage. H. P. Scherer. Explains the methods used in disposing of garbage by total incineration, giving suggestions from experience at Ft. Wayne, Ind., where the crematory has been in success-

ful operation for five years. 3500 w. Munic Engng—Nov., 1900. No. 37461 C.

Pavements.

Construction and Maintenance of Brick Pavements. E. A. Kemmler. Facts concerning paving material used in Columbus, O. Estimates the average life of brick pavements on concrete foundation and with proper maintenance at from eighteen to twenty years. 4400 w. Brick —Nov. 1, 1900. No. 37519.

Refuse Utilization.

Refuse Destruction and the Displacement of Coal. Information from report made to the Rotherhithe Vestry by its surveyor. 1700 w. Ir & Coal Trds Rev—Nov. 9, 1900. No. 37711 A.

Sewage Purification.

Mechanical Aids to Sewage Purification. Illustrated description of apparatus whereby sewage itself can aid in its own purification, the flow of the sewage furnishing the motive power for the periodic feeding of filter beds. 2000 w. Engr, Lond—Nov. 16, 1900. No. 37799 A.

The Proposed Septic Tank and Sewage Purification Studies at Washington University. Reviews the past work in this field, and the proposed further experiments. 2300 w. Eng News—Nov. 15, 1900. No. 37683.

Sewerage.

Converting Portions of the Los Angeles Outfall Sewer Into a Septic Tank. Detailed description of a method of solving a serious engineering difficulty. 4000 w. Eng News—Nov. 8, 1900. No. 37601.

Streets.

Pavement History of Lafayette. W. K. Eldridge. Historical review of local progress from the first efforts at street improvement to the present successful condition. 1300 w. Munic Engng—Nov., 1900. No. 37459 C.

MISCELLANY.

Address.

Presidential Address of Mr. James Monsergh before the British Institution of Civil Engineers. Also editorial. 10200 w. Engng—Nov. 9, 1900. Serial. 1st part. No. 37694 A.

Roads.

Oiled Roads and Their Benefit. Paper by T. F. White, describing the results of sprinkling oil on roads in Southern California. 2500 w. Eng Rec—Nov. 10, 1900. No. 37582.

Wales.

Engineering in Wales. W. H. Preece. An address delivered before the Society of Ancient Britons, Birmingham, Eng. 1800 w. Engng—Nov. 9, 1900. Serial. 1st part. No. 37695 A.

ELECTRICAL ENGINEERING

COMMUNICATION.

Inductance.

The Inductance of Concentric Cables. W. H. Everett. Gives results of investigations, showing that the interior field is not always negligible. 1200 w. Elec Rev, Lond—Nov. 9, 1900. No. 37700 A.

Space Telegraphy.

Experiments on Hertzian Telegraphy with a Telephonic Receiver. An account of some experiments by M. Guarini. Ill. 500 w. Elect'n, Lond—Nov. 9, 1900. No. 37701 A.

Wireless Telegraphy with Repeaters. E. Guarini and Lieut. Poncelet. Remarks on the inconveniences of successive Guarini relays. 500 w. Elec Rev, Lond—Nov. 16, 1900. No. 37790 A.

Telautograph.

Ritchie's Telautograph. An illustrated detailed account of a new writing telegraph and its capabilities. 1500 w. Elect'n, Lond—Nov. 16, 1900. No. 37787 A.

Telegraphs.

The Telegraph System of Siberia. H. L. Geissel. Interesting information concerning the establishment of telegraphic communication across Siberia, showing the country quite advanced in this respect. 1800 w. Elec Wld & Engr—Nov. 17, 1900. No. 37673.

Telephones.

Telephone Pay Systems; Fixed Rentals and Measured Service or Tolls. C. E. McCluer. Reviews the mistakes made in the early systems and shows the need of a reliable recorder, in this first article. 2400 w. Elec Rev, N. Y.—Nov. 14, 1900. Serial. 1st part. No. 37719.

Telephone Service from Messenger Call-Boxes in New York City. Illustrated description of new telephone call-box, and an account of the way in which it will be installed. 800 w. Elec Rev, N. Y.—Nov. 7, 1900. No. 37630.

Telephony in Paris in the Exposition Year. An illustrated account of the service. 1500 w. Elec Wld & Engr—Nov. 3, 1900. No. 37482.

The Independent Telephone System at Pittsburg, Pa., of the Pittsburg and Allegheny Telephone Company. Kempster B.

Miller. Illustrated description of the main exchange, and of the operation of the system adopted. 3500 w. Elec Wld & Engr—Nov. 3, 1900. No. 37480.

The Muskegon, Mich., Independent Telephone Exchange. Illustrated detailed description. 1200 w. Elec Wld & Engr—Nov. 3, 1900. No. 37483.

DISTRIBUTION.

Alternating Currents.

Simple, Complex and Equivalent Harmonic Functions and the Application of Fourier's Series in Alternating Current Circuits. Harold B. Smith. Mathematical, with diagrams. 4400 w. Jour Worcester Polytechnic Inst—Nov., 1900. No. 37911 C.

Distribution.

See Street and Electric Tramways.

Franchises.

Street Franchises for Electric Circuits. Alton D. Adams. A discussion of the powers of towns and cities over their streets. 1200 w. Elec Wld & Engr—Nov. 17, 1900. No. 37674.

Insulation.

The Applications of Porcelain in Electrotechnics (Die Herstellung des Porzellans für die Elektrotechnic). J. Herzog and C. Feldmann. An account of the uses of porcelain in electrical work and a discussion of its properties and preparation. 10000 w. Elektrotech Zeitschr—Nov. 1, 1900. No. 37834 B.

Wiring.

Electric Wiring in Mines. Alton D. Adams. The difficulties which must necessarily be met, and some means of reducing the dangers of faulty insulation. 2000 w. Mines & Min—Nov., 1900. No. 37412 C.

ELECTRO-CHEMISTRY.

Electro-Engraving.

The Riedler Electro-Engraving Apparatus. Illustrated description of a machine exhibited at Paris, explaining the principle of its operation. 700 w. Sci Am—Nov. 3, 1900. No. 37426.

Electro-Galvanizing.

Commercial Electro-Galvanizing. H. H. Thayer, Jr. Describes some of the processes developed by the U. S. Electro Galvanizing Co. Ill. 1500 w. Sib Jour of Engng—Nov., 1900. No. 37734 C.

Fluorine.

Apparatus for the Commercial Production of Fluorine (Appareil pour la Fabrication Industrielle du Fluor). MM. Poulenc et Meslans. A description of an electrolytic process based on that of Moissan. 1200 w. L'Electricien—Nov. 3, 1900. No. 37840 B.

Paris Exhibition.

Electro-Chemistry at the Paris Exhibition. H. Borus. Commences a review of this department and the exhibits. 2800 w. Engng—Nov. 9, 1900. Serial. 1st part. No. 37691 A.

ELECTRO-PHYSICS.

Currents.

The Alteration in Current Forms by the Gratz Aluminum Cell (Ueber die Aenderungen der Stromform eines Normalen Wechselstromes durch Gratz 'sche Aluminumzellen). Dr. G. Mayrhofer. Showing especially the modifications produced in a normal alternating current. Two articles, 5000 w. Elektrotech Zeitschr—Nov. 1, 8, 1900. No. 37836 each B.

Lines of Force.

The Distribution of Lines of Force in Grooved Armatures (Die Vertheilung der Kraftlinien bei Nuthenankern von Gleich und Wechselstrom-maschinen). G. Dettman. An examination of the lines of force for continuous and for alternating current machines. The correctness of the conclusions is shown by the use of iron filings. 5000 w. Elektrotech Zeitschr—Nov. 15, 1900. No. 37848 B.

The Laws of the Distribution of Lines of Force in Alternators (Die Gesetze der Kraftlinienvertheilung ueber den Umfang der Wechselstrommaschinen). Ch. Westphal. A mathematical discussion, with diagrams showing the manner in which the lines of force are distributed around the circumference of an alternator. 3000 w. Elektrotech Zeitschr—Oct. 25, 1900. No. 37830 B.

GENERATING STATIONS.

Alternating Currents.

The Theory of Alternating Dynamo-Electric Mechanism. W. Elwell Goldsborough. Explains the manner in which alternating electro-motive forces are generated in commercial machines, and considers harmonic functions in the present article. 2000 w. Elec Rev, N. Y.—Oct. 31, 1900. Serial. 1st part. No. 37465.

British Stations.

Electric Central Station Practice in England. Frank C. Perkins. The St. Luke's and the Wandsworth stations are described and illustrated as typical examples. 3000 w. Engineering Magazine—Dec., 1900. No. 37865 B.

Dynamos.

Points on Determining Good Designs in Dynamos and Motors. W. L. Woodmansee. How to discriminate between good and bad designs. 1200 w. Engr, U. S. A.—Nov. 1, 1900. No. 37518.

Electricity Works.

Bury St. Edmunds Electricity Works. Brief history of the town and its illumination, with illustrated detailed description of the plant. 3500 w. Elec Engr, Lond—Nov. 2, 1900. No. 37610 A.

Electric Plants.

See Marine and Naval Engineering.

Gas Power.

Electric Plant Operated by Gas. Einar Rasmussen. Describes the generators and engines used to run an electric station in Norway. 800 w. Am Mfr & Ir Wld—Nov. 1, 1900. No. 37479.

Generating Set.

Combined Engine and Dynamo. Illustrated description of a high-speed engine and 220 kilowatt six-pole dynamo. The engine is of 400 h.-p., and is of the three-crank type. 1100 w. Engr, Lond—Nov. 9, 1900. No. 37698 A.

The Cail and Thomson-Houston Generating Set (Groupe Electrogène Cail et Thomson-Houston). Ch. Dantin. The Cail vertical compound engine of the Allis-Corliss design operated a Thomson-Houston alternator of 1000 kilowatts. 1800 w. 1 plate. Génie Civil—Nov. 10, 1900. No. 37804 D.

The Kolben-Carels Generating Set (Groupe Electrogène Kolben-Carels). F. Loppé. Illustrated description of the 1100 h. p. Carels engine and 825 kilowatt three-phase Kolben generator, exhibited together at Paris. 3000 w. L'Electricien —Nov. 17, 1900. No. 37850 B.

India.

Electrical Development Schemes in India. Particulars of a scheme for utilizing the power of Cauvery Falls for working the goldfields of the Kolar district of Mysore. Ill. 2500 w. Elec Rev, Lond—Nov. 2, 1900. No. 37611 A.

Isolated Plant.

An Interesting Residence Lighting Plant. Illustrated description of a plant for lighting a country residence, comprising seven scattered buildings. 1300 w. Eng Rec—Nov. 17, 1900. No. 37779.

The Power Plant of the Massachusetts General Hospital, Boston, Mass. F. W. Dean. Illustrated description of a combined plant for two institutions. 1800 w. Trans Am Soc of Mech Engs, No. 871—Dec., 1900. No. 37755 C.

Kander.

The Electric Station on the Kander (Das Elektricitätswerk an der Kander). Dr. H. Rupp. A fully illustrated description of this important hydraulic electric power station in Switzerland, which supplies the Burgdorf-Thun three-phase electric railway. 5000 w. Elektrotech Zeitschr—Nov. 1, 1900. No. 37833 B.

Paris Exhibition.

French and German Polyphase Generating Units at the Paris Exposition. C. L. Durand. Details of construction and operation of the large machines of the Fives-Lille Co. and the Augsburg-Nuremburg Co. 1600 w. Elec Rev, N. Y.—Nov. 14, 1900. No. 37718.

Power Plants.

See Mechanical Engineering, Hydraulics.

Supply.

Electricity Supply. W. A. Chamen. Read at meeting of the Glasgow Local Section of the Inst. of Elec Engs. Discusses the system and pressure of supply, having special bearing as applied to the city of Glasgow. 3800 w. Elect'n, Lond —Nov. 16, 1900. No. 37788 A.

Winding.

The Computation of Windings (Berechnung des Durchmessers bei Gegebener Zahl der Amperewindungen, der Spulendimensionen, und der Spannung). Arthur Löwit. Deriving convenient formulas for the proper diameter of wire for a given number of ampere turns, coil diameter, and pressure. 600 w. Elecktrotech Zeitschr—Oct. 25, 1900. No. 37831 B.

LIGHTING.

Arcs.

The Alternating Current Arc. C. Wiler. Read before the Chicago Elec. Assn. An account of research work based on the study of the arc by means of the oscillograph. Also editorial. 2400 w. Elec Wld & Engr—Nov. 10, 1900. No. 37594.

Exposition.

The Chateau d'Eau and the Illuminated Fountains (Le Chateau d'Eau et les Fontaines Lumineuses). E. Cayla. Giving details of the construction of the ornate façade of the Electricity Building and the brilliantly illuminated fountains contained in it, and placed before it. 2500 w. Génie Civil—Nov. 3, 1900. No. 37803 D.

Frontier Plant.

A Frontier Electric-Light Plant. George D. Shepardson. Illustrated description of the plant at Gardiner, Mont., a village having a population of about 100 inhabitants. 900 w. W Elect'n—Nov. 10, 1900. No. 37629.

Incandescent.

A New System of Electric Lighting. Illustrates and describes a new system by which the lamps can be placed in any location. It consists in employing surfaces under which positive and negative conductors are interlaced while being insulated from one another. 1300 w. Engr, Lond—Oct. 26, 1900. No. 37645 A.

The Incandescent Lamp. H. D. Bur-

nett. Read at meeting of Peterborough Engng. Club. Reviews the history and development. 6000 w. Can Elec News—Nov., 1900. No. 37655.

Interior Illumination.

A Study of Certain Shades and Globes for Electric Lights, as Used in Interior Illumination. William Lincoln Smith. Illustrated account of tests made upon leading types of shades and globes, with results and description of methods of testing. 6600 w. Tech Quar—Sept., 1900. No. 37500 E.

Lamp Connections.

Standard Connections for Lamps with Edison Screw Contact (Verbande-Normalien und Kaliber lehren für Lampenfüsse und Fassungen mit Edison Gewinde kontakt). R. Hundhausen. An abstract of the official report of the Commission for standardization of incandescent lamp connections. 3000 w. Elektrotech Zeitschr—Nov. 8, 1900. No. 37837 B.

MEASUREMENT.

Accumulators.

The Determination of the Capacity of Accumulators (Ueber die Vorausbestimmung der Erforderlichen Kapacität von Akkumulatorbatterien). C. A. Rossander and E. A. Forsberg. A mathematical discussion, giving a graphical construction, enabling the capacity to be determined for variable discharge. 2500 w. Elektrotech Zeitschr—Oct. 25, 1900. No. 37832 B.

Dielectrics.

Notes on the Testing of Modern Dielectrics at High Voltages. J. Wright. On the present system of testing to guarantee the insulation of the core. 1600 w. Elec Rev, Lond—Oct. 26, 1900. No. 37538 A.

Dynamometer.

A New Transmission Dynamometer. Discussion at Philadelphia, May 16, 1900, of paper by W. Elwell Goldsborough. 2500 w. Trans Am Inst of Elec Engs—Oct., 1900. No. 37727 D.

Meters.

Electric Meters on Power Circuits. P. I. Panamolo. Suggestions concerning the installation and care of the meters. Ill. 1800 w. W Elect'n—Nov. 17, 1900. No. 37916.

Open Circuits.

The E. M. F. of Alternators on Open Circuit. C. C. Hawkins. Discusses the manner of determining the E. M. F. 900 w. Elec Rev, Lond—Oct. 26, 1900. Serial. 1st part. No. 37539 A.

Photometry.

Violle on Contemporary Photometry. A summary of the chief points of interest in this report presented at the Elec. Congress at Paris. 1800 w. Jour Gas Lgt—Oct. 30, 1900. No. 37591 A.

Wheatstone Bridge.

The Calibration of Precision Bridges (Bemerkungen über Aichung von Präcisions-brücken). Dr. M. T. Edelmann. A discussion of the testing and calibration of precision bridges of the Wheatstone type. 1800 w. Elektrotech Zeitschr—Nov. 1, 1900. No. 37835 B.

POWER APPLICATION.

Alternating Currents.

Alternating-Current Motors in a Large Textile Mill. A. F. McKissick. Illustrated description of a water-power development, at Pilzer, S. C. 1700 w. Am Elect'n—Nov., 1900. No. 37484.

Electric Vehicles.

See Mechanical Engineering, Automobilism.

Elevators.

Electric Elevator Control. Hayward Cochrane. Abstract of a paper read before the Chicago Elec. Assn. States the requirements of electric elevator controllers, discusses their operation, etc. Ill. 2700 w. Am Elect'n—Nov., 1900. No. 37486.

Factory Plant.

Electrical Installation of the Milwaukee Harvester Company. Illustrated detailed description of a fine plant. 2500 w. W Elect'n—Nov. 24, 1900. No. 37917.

Induction.

The Induction Motor. B. A. Behrend. The first of a series of essays. A careful treatment of the subject, with much new experimental information. 1800 w. Elec Wld & Engr—Nov. 3, 1900. Serial. 1st part. No. 37481.

Machine Driving.

Electric Power at the Patent Shaft and Axletree Company's Works. Illustrated description of a three-phase electric power installation in England. 1800 w. Engng—Nov. 2, 1900. No. 37612 A.

The Electric Distribution of Power in the Amman Cotton Mills at Pordenone (Distribuzione Elettrica di Forza Motrice nel Cotonificio Amman E. C., in Pordenone). With numerous illustrations showing the manner in which the motors are applied. 2500 w. 1 plate. Industria—Oct. 14, 1900. No. 37841 D.

Mining Plant.

Electricity in Mining. Henry Louis. Abstracts from a series of papers in the *Mining Journal* of London, treating of advanced English and European practice. 2500 w. Mod Mach—Nov., 1900. No. 37566.

Electric Power on the Comstock Lode. Wynn Meredith and Wyatt H. Allen. Il-

lustrated description of a new transmission plant for use of the mines, with editorial notes. 4600 w. Elec Wld & Engr—Nov. 24, 1900. No. 37941.

Shops.

Power and Light for the Machine Shop and Foundry. Forrest R. Jones. Discusses the requirements to be fulfilled by an electric system for power transmission and lighting, and the system selected for a large plant. 6900 w. Trans Am Soc of Mech Engs, No. 882—Dec., 1900. No. 37766 C.

TRANSMISSION.

Insulation.

The Use of Cellulose Paper in Electrotechnics (Ueber die Verwendung der Holzfaser in Form von Papier in der Elektrotechnik). Dr. J. Rabinowicz. Giving a comparison of the insulating value of various materials, and showing the applicability of wood-fibre paper for insulating wire. 3000 w. Elektrotech Zeitschr—Nov. 15, 1900. No. 37849 B.

MISCELLANY.

Address.

Electrical Engineering as a Trade and as a Science. John Perry. Inaugural address delivered at meeting of the Inst. of Elec. Engs., England. 9800 w. Nature—Nov. 8, 1900. No. 37706 A.

Argentina.

Electrical Enterprise in Argentine. Ernesto Danvers. Extracts from a paper read before the Inst. of Engs. of the River Plate, Buenos Aires, Argentina. The present article considers telegraphs, telephones and the electric light. 5000 w. Elec Rev, N. Y.—Nov. 14, 1900. Serial. 1st part. No. 37720.

Paris Exposition.

The Paris Exposition of 1900. Carl Hering. Inaugural address of the president at the meeting of Am. Inst. of Elec. Engs., New York. 10000 w. Trans Am Inst of Elec Engs—Oct., 1900. No. 37-726 D.

Radiography.

Cathode Rays. P. Villard. Abstract of lecture delivered before the Congress of Electricity, in Paris. Describes investigations and gives result of experimental study. 1800 w. Sci Am—Nov. 10, 1900. No. 37556.

The Cathode Stream and X-Light. William Rollins. Considers the ether theory, and the material particle theory, offering suggestions in regard to each. 5000 w. Am Jour of Sci—Nov., 1900. No. 37452 D.

GAS ENGINEERING

Acetylene.

Experiments on the Explosive Power of Acetylene Gas. Robert H. Fenn. Condensed from a graduating thesis presented at the Clarkson School of Technology, Potsdam, N. Y. Illustrates and describes the apparatus used and the tests made. 1600 w. Eng News—Nov. 29, 1900. No. 37934.

The Acetylene Flame. Edward L. Nichols. Reports the progress of investigations upon the properties of the acetylene flame, undertaken for the purpose of determining its usefulness in the physical laboratory. 7800 w. Jour Fr Inst—Nov., 1900. No. 37458 D.

Carbide.

The Application of Blast Furnace Gases to the Manufacture of Calcium Carbide (Die Benutzung der Hochofengase zur Fabrikation von Calcium Carbid). A discussion of the commercial practicability of using furnace gases for the generation of electric current for carbide manufacture. 1800 w. Glückauf—Nov. 10, 1900. No. 37829 B.

Coal Distillation.

Thermic Reactions in the Distillation of Coal. M. Euchêne. Read at Gas Congress at Paris. Gives the principal points in this lengthy communication, and the conclusions drawn from the investigations. Ill. 5700 w. Jour Gas Lgt—Oct. 30, 1900. Serial. 1st part. No. 37592 A.

Coke-Oven Gas.

Coke-Ovens as Gas-Works. From an article by Dr. H. Wiechell, in the *Journal für Gasbeleuchtung*. Examines the financial aspects of the question. 1900 w. Jour Gas Lgt—Nov. 6, 1900. No. 37-679 A.

Conveyors.

See Mechanical Engineering, Power and Transmission.

Gas from Sewage.

Illuminating Gas from Sewage Sludge. Discusses the practicability of obtaining illuminating gas from this source. 2200 w. Jour Gas Lgt—Nov. 6, 1900. No. 37677 A.

Gas Heating.

Heating and Cooking by Gas. Auguste Lévy. Presented at the Paris Congress. On the investigations and tests of the Paris Gas Co., made to advance the use of gas for these purposes. 3400 w. Jour Gas Lgt—Nov. 6, 1900. No. 37678 A.

Gasholders.

Difficulties in the Construction of a Concrete Gasholder Tank. F. G. Cockey. Read before the London meeting of the So. Dist. Assn. of Gas Engs. and Mgrs. A record of personal experience, the difficulties and how met. Also discussion. 4000 w. Gas Wld—Nov. 17, 1900. No. 37784 A.

Gas Light.

Gas Light. A brief review of the history of gas lighting, the improvements in burners, and especially of the invention of Dr. Auer von Welsbach. 4800 w. Contemporary Rev—Nov., 1900. No. 37907 D.

Gas Power.

See Electrical Engineering, Generating Stations.

Guayaquil.

Notes on the Public Lighting of the Town of Guayaquil. Charles Guichard. Read before the Gas Congress at Paris. Description of means and apparatus adopted where defense against nocturnal insects is as necessary as protection from wind, rain, and earthquakes. Ill. 3000 w. Jour Gas Lgt—Oct. 23, 1900. No. 37431 A.

High Pressure.

High-Pressure Gas for Incandescent Lighting. A. W. Onslow. Read at London meeting of the So. Dist. Assn. of Gas Engs. and Mgrs. Gives result of experiments, and discusses the strength of mantles and related subjects. General discussion. 3000 w. Gas Wld—Nov. 17, 1900. No. 37785 A.

Illumination.

Report of the Committee on Research. —To Determine a Useful Working Standard for the Measure of the Illuminating Power of Gas. Describes research work, and gives short topical discussions by various contributors. 5000 w. Pro Age—Nov. 15, 1900. No. 37675.

Incandescence.

Intensified Gas-Lighting (Eclairage Intensif par le Gaz). J. Laverchère. A description of the high economy and brilliant illumination obtained at the Paris Exposition by the use of the Bandsept and the Denayrouze burners using gas at high pressure. 300 w. Génie Civil—Nov. 10, 1900. No. 37805 D.

The Theory of the Incandescent Gas Light. E. G. Love. Read at Denver meeting of the Am. Gas Lgt. Assn. A discussion of the theories and such other subjects as are needed for their clear understanding. 2500 w. Am Gas Lgt Jour—Nov. 5, 1900. No. 37517.

Mantles.

Self-Lighting Mantles. Abstract translation of article by M. Pierron, in the *Revue de Physique et de Chemie*, on the application to mantles of the principle of automatic ignition. 1800 w. Jour Gas Lgt—Oct. 23, 1900. No. 37432 A.

Power Gas.

Motive Power from High Furnace Gases. Bryan Donkin. A critical review of the development of the use of furnace gases for power generation, showing the probable great future of the method. 3500 w. Engineering Magazine—Dec., 1900. No. 37866 B.

Notes on the Question of Power-Gas Application (Beiträge zur Frage der Kraftgasverwerthung). A. Wagener. With special reference to the more recent utilization of furnace gases. 4000 w. 1 plate. Stahl und Eisen—Nov. 1, 1900. No. 37852 D.

Power-Gas Development (Beiträge zur Frage der Kraftgasverwertung). A. Wagener. A general review of the utilization of lean gases for power, with special reference to the large engines of the Oechelhaüser type recently built by the Deutsche Kraftgas-Gesellschaft. Two articles. 3000 w. Zeitschr d Ver Deutscher Ing—Nov. 10, 17, 1900. No. 37844 each D.

Producer Gas.

Notes on the Use of Producer Gas in Burning Bricks. Carl Geissen. Reprint from the Trans. of the Am. Ceramic Soc. Describes the method and its advantages. Also general discussion. 4400 w. Brick —Nov. 1, 1900. No. 37522.

Purifiers.

Notes on Purifier Construction. G. P. Lewis. Read at London meeting of the Southern Dist. Assn. of Gas Engs. and Mgrs. Considers disadvantages of the water seal, proposed improvements in the "dry" system, cost, and the general problem of purification. Also discussion. Ill. 3500 w. Gas Wld—Nov. 17, 1900. No. 37783 A.

Theisen's Centrifugal Gas-Purifying Process. Translated from *Stahl und Eisen*. Illustrated description of the invention and the manner of operating, with information concerning the process. 3000 w. Ir & Coal Trds Rev—Oct. 26, 1900. No. 37529 A.

Pyrometer.

A Blue Glass Pyrometer. E. H. Earnshaw. Read at meeting of the Am. Gas Lgt. Assn. Illustrates and describes the apparatus, which aims to furnish a means of determining temperatures attained in the fixing chambers of water gas apparatus. 1200 w. Am Gas Lgt Jour—Nov. 19, 1900. No. 37716.

Retorts.

Inclined Retorts. A. H. Barret. Read

at Denver meeting of the Am. Gas. Lgt. Assn. Describes the installation and operation of a plant. 3000 w. Am Gas Lgt Jour—Nov. 5, 1900. No. 37516.

Standardization.

The Standardization of Gas-Meter Unions. J. Ferguson Bell. Presidential address before the Midland Assn. of Gas Mgrs., England, with discussion. 8000 w. Jour Gas Lgt—Nov. 13, 1900. No. 37743 A.

Water Gas.

The Removal of Tar from Water Gas. W. C. Morris. Read at meeting of Am. Gas Lgt. Assn. Considers the methods. Illustrations and general discussion. 1700 w. Am Gas Lgt Jour—Nov. 12, 1900. No. 37595.

MARINE AND NAVAL ENGINEERING

Air-Pump Test.

Capacity Test of a Unique Form of Air Pump. F. Meriam Wheeler. Describes a test made to ascertain the capacity of a new design of air pump for surface condensers, and especially intended for marine use. Ill. 2400 w. Trans Am Soc of Nav Archts & Marine Engs—Nov., 1900. No. 37656 D.

Battleships.

Rapid Battleship Building. Waldon Fawcett. Discusses the time economy in battleship construction made during the past two years, particularly in British and American yards. 1800 w. Pop Sci M—Nov., 1900. No. 37407 C.

The Japanese Battleship "Mikasa." An illustrated description of this recently launched vessel. 1400 w. Engng—Nov. 16, 1900. No. 37906 A.

The New Battleships. Illustration, with description of the characteristic features of five powerful vessels which are to be built for the U. S. Navy. 2200 w. Naut Gaz—Nov. 22, 1900. No. 37751.

The New Battleships. Illustration, with description of ships to carry superposed turrets, bearing the names "Georgia," "New Jersey" and "Pennsylvania." 1800 w. Sci Am—Nov. 17, 1900. No. 37650.

The Russian Warship "Novik." A discussion of this vessel and of torpedo boats and craft built to prey upon them. Also a description of the vessel. Ill. 2000 w. Engr, Lond—Nov. 16, 1900. No. 37795 A.

Coaling.

The Coaling of the U. S. S. "Massachusetts" at Sea. Spencer Miller. Describes the apparatus of the marine cableway for coaling at sea, discussing possible improvements and the importance of the work. Fully illustrated. 4000 w. Trans Am Soc of Nav Archts & Marine Engs—Nov., 1900. No. 37662 D.

Cruisers.

German Third-Class Cruiser "Amazone." Brief description, with illustration. 500 w. Engr, Lond—Nov. 2, 1900. No. 37618 A.

The Armored Cruiser "Jeanne d'Arc." Illustrated detailed description. 800 w. Sci Am Sup—Nov. 17, 1900. No. 37652.

The French Cruisers "Cecille" and "Suchet" at New York. Illustrations, with brief descriptions of these vessels. 800 w. Sci Am—Nov. 3, 1900. No. 37425.

Deutschland.

The Twin-Screw Express Steamer "Deutschland" (Der Doppelschrauben Schnelldampfer "Deutschland"). A very complete account of the great Hamburg-American liner, with numerous details of hull and machinery. 10000 w. 5 plates. Zeitschr d Ver Deutscher Ing—Nov. 3, 1900. No. 37814 D.

Doors.

Water-Tight Doors. R. J. Donovan. Comments on types of water-tight doors fitted to bulkheads, and a short description of two of the most modern and their method of operation. 3000 w. Sibley Jour of Engng—Nov., 1900. No. 37733 C.

Electric Plants.

Tests of the Electric Plants of the Battleships "Kearsage" and "Kentucky." J. J. Woodward. Description of tests made to determine if all appliances used were properly constructed and installed, and to collect facts regarding their performance. 20000 w. 68 plates. Trans Am Soc of Nav Archts & Marine Engs—Nov., 1900. No. 37668 H.

Ferryboat.

Fine New Ferryboat. Illustration and description of the "San Pablo," built for service on San Francisco Bay. 1000 w. Naut Gaz—Nov. 8, 1900. No. 37608.

Launching.

The Launch of a Cruiser and a Battleship. James Dickie. Describes the launch of these vessels and also the slips on which they were built. Ill. 3500 w. Trans Am Soc of Nav Archts & Marine Engs—Nov., 1900. No. 37665 D.

Marine Engines.

See Mechanical Engineering, Steam Engineering.

Naval Vessels.

A Comparison of the Contract Prices of

Our Naval Vessels. Harrison S. Taft. Presents data concerning the relative cost of the vessels of each of the seven classes, the prices between different firms, the relative prices of different classes, and the tendency of prices. 3500 w. Trans Am Inst of Nav Archts & Marine Engs—Nov., 1900. No. 37664 D.

Recent Designs of Battleships and Cruisers for the United States Navy. Philip Hichborn. A description of the latest naval designs, supplemented by data and outline plans, without discussion of the merits or special features. 4300 w. Trans Am Soc of Nav Archts & Marine Engs—Nov., 1900. No. 37659 F.

Paris Exhibition.

The Messageries Maritimes at the Paris Exhibition. Detailed description, with illustrations, of the exhibits and the pavilion containing them. 1800 w. Engng—Nov. 16, 1900. No. 37904 A.

Reconstruction.

Rebuilding a Steamer on the Tyne. Describes the reconstruction of the Italian passenger steamer "Savoia." 600 w. U. S. Cons Repts, No. 874—Oct. 31, 1900. No. 37424 D.

Rules.

Classification Rules. Theodore Lucas. Remarks on the influence of classification regulations for the guidance of underwriters on the development of our merchant marine. Gives Lloyd's Rules, and the proposed standard specifications of the Am. Sec. of the International Assn. for Testing Materials. 6000 w. Trans Am Soc of Nav Archts & Marine Engs—Nov., 1900. No. 37667 D.

School Ship.

New York School Ship "St. Mary's." Illustration, with account of the service of this vessel. 600 w. Marine Engng—Nov., 1900. No. 37562 C.

Shipbuilding.

Can the American Shipbuilder Under Present Conditions Compete with the British and German Shipbuilders in the Production of the Largest Class of Ocean Passenger and Freight Steamships? George W. Dickie. Presents a comparison in skill in design, cost of labor, and cost of material. 3800 w. Trans Am Soc of Nav Archts & Marine Engs—Nov., 1900. No. 37660 D.

Notes on Recent Improvements in Foreign Shipbuilding Plants. H. G. Gillmor. The paper is based on observations made during recent visits, as compared with visits made several years ago. 2300 w. Trans Am Soc of Nav Archts & Marine Engs—Nov., 1900. No. 37661 D.

Speed.

The Steaming Radius and the Most Economical Speed of Steam Vessels. Facts concerning the "El Sud," purchased by the United States and renamed "Yosemite," taken from an article by M. E. Cooley, published in *Technic*. 800 w. Eng News—Oct. 18, 1900. No. 37543.

Steamships.

Atlantic Steamships — Present and Future. Drawings and comparative data of the two classes of vessels now in favor, as represented by the "Ivernia" and the "Deutschland." Also editorial. 3200 w. Sci Am. Nov. 10, 1900. No. 37555.

Magnificent American Steamship for Coasting Service. Illustration, with a complete description, of the "Morro Castle," a steamer displacing over 8000 tons, and finely fitted. 3000 w. Naut Gaz—Nov. 15, 1900. No. 37723.

Transatlantic Liner "Commonwealth." Brief illustrated description of fine vessel for the Boston-Liverpool trade. 500 w. Marine Engng—Nov., 1900. No. 37563 C.

Steam Turbines.

The Steam Turbine in Large Merchant Steamers. George W. Melville. Gives personal views on the use of the turbine. Does not think it at present in a position to replace the reciprocating engine. 1400 w. Sci Am—Nov. 24, 1900. No. 37739.

Turbine Engines. Charles A. Parsons. in a letter to the London *Times*. Statement of the inventor regarding the trials of the "Viper." 1400 w. Naut Gaz—Nov. 8, 1900. No. 37609.

Submarine.

Construction and Machinery of the French Submarine Boats (Bau und Mechanismus der Französischen Unterseeboote). B. Denninghoff. A general account of the various experimental boats since 1888, and reference to those to be laid down in 1901. 2000 w. Schiffbau—Nov. 8, 1900. No. 37820 D.

Torpedo Boats.

The Safety of Torpedo Boats at Sea and in Action Under Various Conditions. Lloyd Bankson. Describes briefly what may be expected to occur when these vessels are seriously injured or in danger in bad weather, and what chances they may have of keeping afloat. 3 plates. 1000 w. Trans Am Soc of Nav Archts & Marine Engs—Nov., 1900. No. 37666 D.

Trial Tank.

The United States Experimental Model Basin. D. W. Taylor. A description of the basin and its appliances, fully illustrated. 7000 w. Trans Am Soc of Nav Archts & Marine Engs—Nov., 1900. No. 37658 F.

Units.

Interchangeability of Units for Marine Work. W. D. Forbes. Illustrations and suggestions concerning a proposed system. 1500 w. Trans Am Soc of Nav

Archts & Marine Engs—Nov., 1900. No. 37657 D.

Wharves.

A Timber Steamship Pier and Shed. Illustrated description of a heavy pier at Hoboken, N. J., designed for transatlantic steamship service. 1500 w. Eng Rec—Nov. 3, 1900. No. 37504.

Yachts.

A Composite Torpedo Boat. Illustrated detailed description of Charles R. Flint's "Arrow," which can be transformed from a torpedo-boat, carrying a complete armament, to a yacht, which may be used as a dispatch boat. 3500 w. Ir Age—Nov. 22, 1900. No. 37728.

S. Y. "Arrow," Designed to Steam at the Rate of 40 Knots. Illustration and description of a vessel designed to attain the highest possible speed. 3000 w. Marine Engng—Nov., 1900. No. 37561 C.

The "Arrow." Full illustrated description of this fine high-speed vessel. 3200 w. Naut Gaz—Nov. 1, 1900. No. 37515.

The Twin-Screw Steam Yacht "Arrow." Illustrated description of a boat and its machinery designed for the attainment of extreme speeds. 3500 w. Sci Am Sup—Nov. 3, 1900. No. 37429.

MECHANICAL ENGINEERING

AUTOMOBILISM.

Auto-Trucks.

The Heavy Auto-Truck in Great Britain and the United States. Robert Bodman. Considers the methods in Gt. Britain and compares the conditions with those prevailing in the United States; the possibilities of its proving a paying investment, and gives the writer's views. 2000 w. Horseless Age—Nov. 7, 1900. No. 37642.

Brakes.

Report on Brakes, Presented at the International Automobile Congress. M. L. Bochet. A discussion of devices and methods used in the operation of automobiles. 4000 w. Horseless Age—Nov. 21, 1900. No. 37738 C.

Electric Vehicles.

Electric Vehicles at the Madison Square Garden Show. P. M. Heldt. Reviews features of interest in the exhibits, showing the progress made. 2800 w. Horseless Age—Nov. 7, 1900. No. 37637.

Exhibition.

Exhibits at the Automobile Club's Show. Brief notice of the exhibits at Madison Sq. Garden, with illustrations. 3500 w. Horseless Age—Nov. 7, 1900. No. 37635.

The Exhibition. E. J. Stoddard. A review of the exhibits at Madison Square Garden, New York. 2500 w. Horseless Age—Nov. 7, 1900. No. 37638.

The Loan Exhibition of the Automobile Club. R. I. Clegg. Brief comments on the vehicles shown in this department at Madison Sq. Garden. 2900 w. Horseless Age—Nov. 7, 1900. No. 37643.

Fire Equipment.

Automobile Fire Equipment of Paris. Illustrated description of fire apparatus used at the French capital since March, 1899. 700 w. Fire & Water—Nov. 17, 1900. No. 37714.

French Trials.

The French Automobile Trials. G. A. Burls. An account of the trials at Vincennes, in connection with the Paris Exhibition. 2500 w. Auto Jour—Nov., 1900. No. 37782 A.

Locomobiles.

A Steam Motor Carriage. Illustrates and describes a vehicle to carry four persons, and gives some facts regarding its operation. 1700 w. Engr, Lond—Nov. 9, 1900. No. 37699 A.

Motor Cars.

Motors Cars as Feeders to Tramways and Otherwise. Henry Mozley. Illustrated description of a vehicle for carrying passengers either along country roads or in the city. 400 w. Tram & Ry Wld—Oct. 11, 1900. No. 37444 A.

The Wolseley Car. Illustrates and describes the car and the motor, which is a single-cylinder water-cooled engine, using petroleum spirit. 600 w. Engr, Lond—Oct. 26, 1900. No. 37533 A.

Motors.

Critical Review of the Carriages and Engines of the So-Called "Explosive Type" shown in the Recent Exhibition. Henry Power. 2500 w. Horseless Age—Nov. 14, 1900. No. 37676.

Hub Motor Automobiles. Brief illustrated description of vehicle with motor built into the hub of the wheel, so that no gearing of any sort is visible. 350 w. Elect'n, Lond—Oct. 26, 1900. No. 37535 A.

Novelties in Air-Cooled Motors at the Automobile Club's Show. Clarence C. Bramwell. Brief notice of the new examples. 600 w. Horseless Age—Nov. 7, 1900. No. 37644.

Steam and Gas Engines in Automobiles. R. H. Thurston. A discussion of some of the difficulties met in self-propelled vehicles. 2700 w. Horseless Age—Nov. 7, 1900. No. 37636.

Obstacles.

Resistance of Obstacles. Ernest J. Loring. Diagrams intended to explain the relation existing between the weight carried by a wheel, and the power required to force it over an obstacle. 600 w. Horseless Age—Nov. 21, 1900. No. 37737 C.

Running Gear.

American Tendencies in Automobile Running Gears. Herbert L. Towle. A review of present practice in America, and brief notice of European practice. Ill. 2000 w. Horseless Age—Nov. 7, 1900. No. 37640.

Selden Patent.

The Selden Patent Suit. Particulars of an interesting suit for patent infringement that may have the effect, if sustained, of closing the shops of many automobile makers. Ill. 1800 w. Sci Am—Nov. 24, 1900. No. 37741.

Speed Gear.

The Change Speed Question at the Automobile Club. Comments on the lack of progress in the devices used, and a discussion of the requirements. 1500 w. Horseless Age—Nov. 7, 1900. No. 37641.

Steam Vehicles.

Economy in Steam Vehicles. E. C. Oliver. The object of the paper is to point out certain lines along which improvement may be made. 3400 w. Horseless Age—Nov. 21, 1900. No. 37736 C.

Steam Vehicles at the Show. R. I. Clegg. A review of the exhibits at Madison Sq. Garden, with comments. 2800 w. Horseless Age—Nov. 7, 1900. No. 37639.

Trials.

Electric Motor Car Trials. An account of the trials of electric motor cars made near London, Eng. Ill. 2200 w. Elec Rev, Lond—Nov. 16, 1900. No. 37791 A.

HYDRAULICS.

Compressed Air.

Pumping by Compressed Air. Edward A. Rix. The object of the paper is to discuss some neglected points, suggest some new methods, and encourage the designing of pumps especially adapted to the use of compressed air. Ill. 14000 w. Jour Assn of Engng Socs—Oct., 1900. No. 37909 C.

Lift Pumps.

Moving Water Horizontally by Air-Lift Pumps at Point Pleasant, Pa. Condensed from the *Metal Worker*. Clark Howell. An illustrated account of the plant. 2000 w. Eng News—Nov. 22, 1900. No. 37925.

Lifts.

The New Hydraulic Lifts for the Eiffel Tower (Les Nouveaux Ascenseurs Hydrauliques de la Tour de 300 Metres). Ch. Dantin. A fully illustrated account of the new lifts installed to accommodate the increased travel at the Exposition of 1900. 2000 w. 1 plate. Génie Civil—Oct. 20, 1900. No. 37800 D.

Power Plant.

Another Great Hydraulic Power Plant. A full illustrated account of the St. Lawrence Power Company's undertaking, at Massena, N. Y. 3500 w. Ir Age—Nov. 8, 1900. No. 37571.

The St. Lawrence Power Company's Plant at Massena, N. Y. Brief illustrated description of interesting features. 1900 w. Sci Am—Nov. 17, 1900. No. 37649.

The St. Lawrence Power Plant at Massena. Illustrated description of works for an initial development of 37,500 h.-p., and final development of 150,000 h.-p. 1800 w. Eng Rec—Nov. 3, 1900. No. 37503.

Pumping Engines.

Barr Pumping Engine at Washington, D. C. Illustrated description, with extract from the report of the official test. 1000 w. Power—Nov., 1900. No. 37453.

Pumping Engines for the Coolgardie Pipe Line. Illustrated description of one of the six-cylinder, triple-expansion engines to be furnished for this pipe line in West Australia. The purpose is to supply water to the mining district, a distance of 325 miles. 1400 w. Eng News—Oct. 18, 1900. No. 37548.

Pump Tests.

Tests of Centrifugal Pumps. W. B. Gregory. Illustrations and description of two centrifugal pumps. 2000 w. Trans Am Soc of Mech Engs, No. 869—Dec., 1900. No. 37753 C.

Turbines.

Turbines. Arthur Henry Tyack. Read before the Inst. of Civ. Engs., Manchester, Eng. Part first gives description of various types. 1800 w. Elec, Lond—Nov. 2, 1900. Serial. 1st part. No. 37602 A.

Water Measurements.

Water Measurements in Connection with a Test of a Centrifugal Pump at Jourdan Avenue Drainage Station, New Orleans, La. W. M. White. States the object of the test, and gives an illustrated detailed description, with discussion of results. 3700 w. Jour Assn of Engng Socs—Oct., 1900. No. 37908 C.

MACHINE WORKS AND FOUNDRIES.

Brass Founding.

The Use of Scrap Metals in Alloying. C. Vickers. Suggestions for the sorting and use of scrap. 1800 w. Am Mach—Nov. 1, 1900. No. 37436.

Yellow Brass Scrap. C. Vickers. Suggestions for making brass castings. 1700 w. Am Mach—Nov. 8, 1900. No. 37559.

Castings.

The Burning or Mending of Castings. Edward B. Gilmore. Describes the successful work of the writer, giving suggestions. Ill. 900 w. Jour Am Found Assn—Vol. 14, Part I. No. 37523 C.

The Orth Casting Apparatus. From *Stahl und Eisen.* Illustrated description of apparatus intended to facilitate the casting of molten iron into several rows of metallic moulds at once. 700 w. Col Guard—Nov. 2, 1900. No. 37615 A.

Centrifugal Fans.

Note on Centrifugal Fans for Cupolas and Forges. William Sangster. Formulæ for the power required, with explanatory notes. 1200 w. Trans Am Soc of Mech Engs, No. 872—Dec., 1900. No. 37756 C.

Connecting Rods.

Manufacturing Connecting Rods for Steam Engines. Describes the methods used in the manufacture. 1300 w. Am Mach—Nov. 15, 1900. No. 37648.

Cost Keeping.

Cost Keeping at the Chicago Works of Fraser & Chalmers. Describes a system that has been in satisfactory operation for four years. 2200 w. Am Mach—Nov. 1, 1900. Serial. 1st part. No. 37434.

The Expense Account of the Machine Shop. Horace L. Arnold. A discussion of an important element in cost keeping, showing the true method of treating indirect factory expenditures. 3500 w. Engineering Magazine—Dec., 1900. No. 37861 B.

Crucibles.

How Crucibles Are Made. H. C. Hovey. Interesting information relating to the process of manufacture, materials used, etc. 2000 w. Sci Am Sup—Nov. 24, 1900. No. 37742.

Flow of Metal.

A Remarkable Case of the Flow of Metal Under Pressure. F. A. Halsey. Illustrates and describes the results of some experimental work. 1000 w. Am Mach—Nov. 22, 1900. No. 37731.

Foundry.

The Foundry of the General Electric Company at Schenectady, N. Y. C. L. Prince. An illustrated detailed description of a large foundry. 3000 w. Jour Am Found Assn—Vol. 14, Part I. No. 37524 C.

Fuels.

Cupola Fuels. Edward Kirk. An account of experiments made with gas and liquid fuels, and charcoal fuel. 2200 w. Foundry—Nov., 1900. No. 37449.

Inspectors.

Shop and Mill Inspectors and Their Work. W. O. Henderer. The need of inspection is shown, and an account given of the methods adopted by the inspection department of the Osborn Engng Co., of Cleveland, O. 7500 w. Jour Assn of Engng Socs—Sept., 1900. No. 37446 C.

Jig.

A Drilling and Tapping Jig. Joseph V. Woodworth. Illustrated description of a jig for drilling and tapping a cast-iron hood. 600 w. Am Mach—Nov. 29, 1900. No. 37928.

Mixing.

Mixing Iron by Analysis. W. G. Scott. Describes the methods used in several large foundries making gray iron, malleable and steel castings, also brass and bronze work. 4800 w. Foundry—Nov., 1900. Serial. 1st part. No. 37450.

Molding.

Machine Molding. I. L. McCord. Read at meeting of the Foundrymen's Assn. Discusses some of these machines, their advantages and disadvantages, cost, etc. 4800 w. Ir Age—Nov. 8, 1900. No. 37573.

Molds.

Mold Construction for Crayons and Lead Balls. Joseph V. Woodworth. Illustrated description. 1400 w. Am Mach—Nov. 15, 1900. No. 37646.

Pyrometer.

A New Recording Air Pyrometer. William H. Bristol. Describes an instrument designed to measure temperature of high ranges, and to give continuous record of changes. 900 w. Trans Am Soc of Mech Engs, No. 883—Dec., 1900. No. 37767 C.

Shop Equipment.

The Floor-Plate Portable Tool System of Handling Heavy Work at the Works of the General Electric Company. Illustrations and description, showing the utility of this system. 700 w. Am Mach—Nov. 29, 1900. No. 37927.

Steel Balls.

A New System for the Manufacture of Steel Balls. Illustrated description of the system used by the Steel Ball Company, of Chicago, for producing balls of any required size. 3300 w. Am Mach—Nov. 1, 1900. No. 37433.

Twisting.

A Twisting Operation. C. H. Rowe. Illustrates and describes the essential features of a recently constructed punch and die for twisting the ends of sheet metal. 700 w. Am Mach—Nov. 1, 1900. No. 37435.

Works Organization.

The Meaning of Commercial Organization of the Workshop. A. Hamilton Church. A discussion of the requisite basis of success under modern manufacturing conditions. 3500 w. Engineering Magazine—Dec., 1900. No. 37863 B.

Workshops.

Comfortable Work Shops. Editorial on the profitableness of keeping shops comfortably warm, well lighted, in good sanitary condition, etc. 1700 w. Ir Age—Nov. 8, 1900. No. 37575.

MATERIALS OF CONSTRUCTION.

Cast Iron.

The Chemistry and Physics of Cast Iron. Continued discussion of Mr. Kreuzpointner's paper, entitled "Riddles Wrought in Iron and Steel." Ill. 8500 w. Jour Fr Inst—Nov., 1900. No. 37457 D.

Elastic Limit.

The Relation of the Elastic Limit to the Rupture of a Material (Welche Umstände Bedingen die Elastizitätgrenze und den Bruch eines Materiales?). O. Mohr. A mathematical investigation of the conditions of rupture, discussing old and new theories and the deductions to be made from an observed elastic limit. Two articles. 8000 w. Zeitschr d Ver Deutscher Ing—Nov. 10, 17, 1900. No. 37845 each D.

Metals.

Hardness, or the Workability of Metals. W. J. Keep. Describes the machine constructed for testing, and gives examples of experimental work, with tabulated results. Ill. 3300 w. Trans Am Soc of Mech Engs, No. 879—Dec., 1900. No. 37763 C.

Note on the Structure of Phosphoretic Pig Metals. J. E. Stead. From Pro. Cleveland Inst. of Engs. An illustrated study of this metal. 700 w. Metallographist—Oct., 1900. No. 37770 E.

Paints and Varnishes.

The Composition and Classification of Paints and Varnishes. A. H. Sabin. A discussion of these substances, their various kinds and uses, and the considerations that should govern the choice and use. 1200 w. Trans Am Soc of Nav Archts & Marine Engs—Nov., 1900. No. 37663 D.

Specifications.

Specifications for Foundry Materials. Gives specifications used by the J. I. Case Threshing Machine Company of Racine, Wis. 5500 w. Ir Age—Nov. 1, 1900. No. 37440.

Specifications for Moulding Sand. Specifications under which the purchases for the J. I. Case Threshing Machine Co. are made. 2000 w. Ir & Coal Trds Rev—Nov. 16, 1900. No. 37794 A.

The International Association for Testing Materials. Their discussion of proposed specifications at the meeting held Oct. 25, 26 and 27. 6800 w. Ir Age—Nov. 1, 1900. No. 37441.

Steel.

The Internal Architecture of Steel. J. O. Arnold. Read in the Mech. Sci. Section of the British Assn. for the Adv. of Science. An illustrated study of this subject. 2800 w. Metallographist—Oct., 1900. No. 37771 E.

Testing.

A New Method for Testing Materials (Nouvelle Méthode pour l'Essai des Materiaux). Ch. Frémont. A paper read before the International Congress for Testing Materials, describing the improvements of the author in the bending test. 7000 w. Revue de Mécanique—Oct. 31, 1900. No. 37806 H.

POWER AND TRANSMISSION.

Conveying.

A Cableway Hoisting and Conveying Apparatus, with Traveling Electric Motor. Illustrated detailed description. 700 w. Eng News—Nov. 15, 1900. No. 37682.

Mechanical Conveyance of Coke in the Paris Gas Company's Works. M. Louvel. Read before the Gas Congress at Paris. Illustrated description of these mechanical arrangements. 5000 w. Jour Gas Lgt—Oct. 23, 1900. No. 37430 A.

Compressed Air.

A 150-Horse-Power Three-Stage Compressor. Description of a new type of compressor for carbonic acid gas, to work against a pressure of 1,200 lbs. 500 w. Eng Rec—Nov. 3, 1900. No. 37508.

Compressed Air for the Transmission of Power. J. H. Ronaldson. Read before the N. S. W. Chamber of Mines. Considers the laws affecting the compression of air, compressors, efficiency, methods of using and dangers. 3500 w. Compressed Air—Nov., 1900. No. 37590.

Gears.

A New Speed-Changing Gear. Illustrated description, with explanation of the principles upon which it works. 1300 w. Eng News—Nov. 15, 1900. No. 37688.

Mills.

Power and Power Transmission for Mills. Henry James Lamborn. The first of a series of articles on the supply of energy in the most efficient and economical manner. 1200 w. Mod Mach—Nov., 1900. No. 37565.

Moving Stairway.

A New Moving Stairway. Illustrated detailed description of the link-belt mov-

ing stairway, invented by J. M. Dodge. 700 w. Eng News—Oct. 18, 1900. No. 37546.

Traveling Stairways for the Elevated Railways, New York. Illustrates and describes details of a moving stairway being erected at the 23d St. Station of the 6th Ave. branch of the Manhattan Elevated system. 500 w. Sci Am—Nov. 17, 1900. No. 37651.

Rope Driving.

Rope Driving. H. J. Nichols. Read before the British Inst. of Draughtsmen. Brief discussion of the advantages and systems used. 1500 w. Prac Engr—Nov. 16, 1900. No. 37789 A.

Speed-Varying.

The Dieterich Speed-Varying Device. Illustrated description of the Dieterich gear, and some of its applications. 1800 w. Am Mach—Nov. 22, 1900. No. 37730.

SPECIAL MOTORS.

Banki Motor.

Experiments with the Banki Motor. E. Meyer. From the *Zeitschrift des Vereines Deutscher Ingenieure*. Illustrated description of the new form of the Banki motor. Also a comparison of the Diesel and Banki motors, with remarks on their application to motor vehicles. 4200 w. Auto Jour—Nov., 1900. Serial. 1st part. No. 37781 A.

Diesel.

Diesel's Motor at Paris. Extracts from a paper on recent tests of his engine, read by Mr. Diesel, giving comparisons of how it worked with various kinds of gas. 900 w. Am Mfr & Ir Wld—Nov. 22, 1900. No. 37769.

The Diesel Thermic Motor (Le Moteur Thermique Diesel). R. Diesel. A paper presented by the inventor at the International Congress of Mechanics at Paris, giving the most recent results and experiences with the Diesel motor. 6000 w. Revue de Mécanique—Oct. 31, 1900. No. 37807 H.

Gas and Oil.

Gas and Oil Engines. Discusses the fundamental principles, the cycle, gas engine performance, valve gear and governors, igniters, two-cycle engines, oil engine operation, etc., giving illustrated descriptions of numerous types. 25000 w. Power Quar—Oct. 15, 1900. No. 37919 C.

Gas Engines.

A New Principle in Gas-Engine Design. C. E. Sargent. Discusses the disadvantages of modern gas engines, and the writer's efforts to overcome these disadvantages, giving an illustrated description of the engine designed. 6800 w. Trans Am Soc of Mech Engs, No. 870—Dec., 1900. No. 37754 C.

Heat Efficiency of a Gas Engine as Modified by Point of Ignition. C. V. Kerr. An account of tests made in the gas engine laboratory of the Armour Inst. of Technology, with conclusions reached. 1600 w. Trans Am Soc of Mech Engs, No. 880—Dec., 1900. No. 37764 C.

I. Should a Gas Engine Be Compounded? E. W. Roberts. II. Successful Compounding Improbable. C. V. Kerr. III. Why It Is Unnecessary to Compound a Gas Engine. C. E. Sargent. A series of articles discussing the subject of compounding, both in theory and practice, with editorial. 4000 w. Mod Mach—Nov., 1900. No. 37504.

The Gas Engines at the Paris Exhibition. An illustrated review of the exhibits in this field. 6500 w. Power Quar—Oct. 15, 1900. No. 37918 C.

250 Horse-Power Gas Engine. An illustrated description of an exceptionally large gas engine. 900 w. Engr, Lond—Nov. 16, 1900. No. 37797 A.

Hydrocarbons.

Explosive Mixtures of Air and Hydro-Carbon Vapors (Sur les Mélanges Explosifs Formés par l'Air et par les Vapeurs des Hydrocabures). J. Meuméur. An investigation of the best mixture of air and vapor for perfect combustion. 1000 w. Comptes Rendus—Oct. 15, 1900. No. 37817 D.

Motors.

See Mechanical Engineering, Automobilism.

Secor Engine.

The Secor Internal Combustion Engine. Illustrated description of a single cylinder kerosene oil engine directly connected to a generator, all being mounted on a common base. 1100 w. Ir Age—Nov. 1, 1900. No. 37439.

STEAM ENGINEERING.

Blowing Engines.

See Mining and Metallurgy, Iron and Steel.

Boilers.

Comparison of Rules for Calculating the Strength of Steam Boilers. H. de B. Parsons. Calls attention to variations in the rules now in use, in the hope of eliciting a full discussion of the desirability of preparing a set of standard rules. 900 w. Trans Am Soc of Mech Engs, No. 876—Dec., 1900. No. 37760 C.

The Strength of Boiler Shells (Beitrag zur Festigkeitsberechnung der Kesselwände). W. Conrad. A theoretical investigation of the weakening effect of openings cut in boiler shells and the proper method of reinforcement. Two articles, 7000 w. Zeitschr d Oesterr Ing

u Arch Ver—Oct. 26, Nov. 9, 1900. No. 37816 each B.

Boiler Trials.

Boiler Trials and Analyses of Fuel and Chimney Gases. Abstract translation of a communication by H. Bunte, in response to a request for a set of rules for carrying out efficiency trials of boilers and steam-engines. 4500 w. Jour Gas Lgt—Oct. 30, 1900. No. 37593 A.

Tests of the Boiler of the Purdue Locomotive. W. F. M. Goss. Briefly describes the locomotive and its boiler, and the tests. Ill. 7200 w. Trans Am Soc of Mech Engs, No. 878—Dec., 1900. No. 37762 C.

Calorimeter.

A New Form of Calorimeter for Measuring the Wetness of Steam. John Goodman. Illustrated description of a new form of instrument designed by the author, and the method of using it. 2500 w. Prac Engr—Oct. 26, 1900. No. 37537 A.

The Steam Calorimeter. A. F. Nagle. Explains the principles upon which those in common use are designed, and their present development. Ill. 1600 w. Am Elect'n—Nov., 1900. No. 37485.

Central Valve.

An American Central Valve Engine. E. T. Adams. Describes the valve gear of an engine, the result of an effort to work the central valve idea in a form to meet existing conditions in America. 1800 w. Trans Am Soc of Mech Engs, No. 874—Dec., 1900. No. 37758 C.

Engine Specifications.

Specifications for Steam Engines. William H. Bryan. Letter on the best method of writing specifications for engines for any service. 1000 w. Eng Rec—Nov. 3, 1900. No. 37512.

Exhaust Pipes.

Exhaust Pipes for Condensing Engines. Discusses the faults in the design of exhaust pipes. 1000 w. Eng Rec—Nov. 7, 1900. No. 37773.

Exhaust Steam.

Heating Value of Exhaust Steam at Electric Stations. Alton D. Adams. A discussion of the various methods of utilizing the exhaust steam and so adding very materially to the present revenues. 3200 w. Elec Rev, N. Y.—Nov. 14, 1900. No. 37717.

Exposition.

Steam Engines at the Paris Exposition, 1900 (Die Dampfmotorenan der Weltausstellung in Paris, 1900). A. Stodola. The first installment treats of the exhibits of Gebrüder Sulzer, of Zurich. 1800 w. 1 plate. Schweizerische Bauzeitung—Oct. 27. 1900. No. 37822 B.

Steam Engines at the Exposition of 1900. From *La Nature*. Brief summary of the striking peculiarities among the exhibits, with illustrations. 2700 w. Sci Am Sup—Nov. 17, 1900. No. 37653.

Feed Waters.

The Cold Purification of Boiler Feed Waters. Albert A. Cary. Discussion of N. O. Goldsmith's paper on the Water Softening Plant at the Lorain Steel Co.'s Blast Furnaces, read at the Cincinnati meeting of A. S. M. E. 1300 w. Power—Nov., 1900. No. 37455.

Fuel.

Liquid Fuel. E. L. Orde. Read before the N. E. Coast Inst. of Engs. and Shipbuilders. Practical results of some experiments made by the writer, with conclusions. 2800 w. Col Guard—Nov. 16, 1900. No. 37902 A.

High-Speed.

A Record of the Early Period of High-Speed Engineering. Charles T. Porter. Reminiscences of John F. Allen, and of the infancy of high-speed steam engineering. 1400 w. Trans Am Soc of Mech Engs, No. 877—Dec., 1900. No. 37761 C.

High-Speed Steam Engine and Governor (Schnellaufende Ventildampfmaschinen und Flachregler). Fr. Freytag. An illustrated description of the Lentz high-speed steam engine, using poppet valves and shaft-governor. 4500 w. 1 plate. Zeitschr d Ver Deutscher Ing—Oct. 27, 1900. No. 37813 D.

Indicators.

Apparatus for Dynamically Testing Steam-Engine Indicators. Carleton A. Read. Illustrates and describes the apparatus and its use. 1300 w. Trans Am Soc of Mech Engs, No. 873—Dec., 1900. No. 37757 C.

Indicator Cards. Alfred Siebert. Explains how indicator cards show what is going on inside the cylinder. 3200 w. Ice & Refrig—Nov., 1900. No. 37513 C.

Marine Engines.

Modern Marine Engines (Moderne Schiffsmaschinen). R. J. Sanzin. A review of changes in design and proportion resulting from increase in speed and pressure. 3000 w. Schiffbau—Oct. 23, 1900. No. 37818 D.

Slide Valves.

Simple Slide Valves and Link Motions. J. Dowling. A solution of the various problems by graphical methods. Ill. 2000 w. Prac Engr—Oct. 26, 1900. Serial. 1st part. No. 37536 A.

Steam Turbine.

The Steam Turbine: The Steam Engine of Maximum Simplicity and of Highest Thermal Efficiency. Robert H. Thurston. A summary of the work of the steam

turbine to date, and a study of the sources of loss as it is now constructed and operated, and the principles of its correct design, construction and operation, with other related information. Ill. 18500 w. Trans Am Soc of Mech Engs, No. 881—Dec., 1900. No. 37765 D.

See Marine and Naval Engineering.

Valve Diagram.

The Application of Sweet's Diagram to the Meyer Valve. J. Begtrup. Explains the fundamental principles of cut-off valves, the Meyer cut-off diagram, and its limitations. 1600 w. Am Mach—Nov. 8, 1900. No. 37558.

Water-Tube.

Investigations Upon Babcock & Wilcox Boilers (Versuche an Babcock und Wilcox Kesseln). C. Züblin. Comparing the results of tests upon Babcock & Wilcox marine boilers with those of other types. 4000 w. Schiffbau—Nov. 8, 1900. No. 37819 D.

Water Tube Steam Generators for Naval Service. B. H. Thwaite. A very full discussion of the various types and their especial fitness for naval use. 6000 w. Engineering Magazine—Dec., 1900. No. 37860 B.

See Mechanical Engineering, Steam Engineering.

MISCELLANY.

Armor.

Armor and Guns. Ira N. Hollis. Historical review of ordnance development. 3500 w. Jour Worcester Polytechnic Inst—Nov., 1900. No. 37910 C.

Contracts.

Letting Contracts Without Competition. An editorial discussion of the subject as illustrated by the armor-plate contracts. 2200 w. Eng News—Nov. 22, 1900. No. 37924.

The Construction of Contracts. Reginald Pelham Bolton. Suggestions designed to lead to the preparation of a more suitable form of contract than is now usually available. 3800 w. Trans Am Soc of Mech Engs, No. 885—Dec., 1900. No. 37768 C.

Integrator.

A Mechanical Integrator Used in Connection with a Spring Dynamometer. Max H. Wickhorst. Illustrated description of an integrator designed by the author for use in the dynamometer car of the C. B. & Q. R. R., for the purpose of showing the average drawbar pull. 600 w. Trans Am Soc of Mech Engs, No. 875—Dec., 1900. No. 37759 C.

Rifle.

The Lee Straight-Pull Magazine Rifle. E. G. Parkhurst. Illustrated description, with statement of the advantages claimed for the straight pull system. 2500 w. Am Mach—Nov. 22, 1900. No. 37729.

Velocity.

Velocity Diagrams. Dexter S. Kimball. Gives a method of finding the velocity diagram, and its value in machine design. Ill. 2500 w. Sib Jour of Engng—Nov., 1900. No. 37732 C.

MINING AND METALLURGY

COAL AND COKE.

Briquettes.

The Manufacture of Peat Briquettes (Ueber die Fabrikation von Torfbriketts). Dr. B. Kosmann. Discussing principally the value of compressed peat as fuel, including the cost of manufacture into briquettes. 3000 w. Glückauf—Nov. 3, 1900. No. 37828 B.

Coal-Cutting.

Mechanical Coal-Cutting in America. M. A. Bachellery. From a paper prepared for the Congress at Paris. Illustrates and describes machines and considers the results. 4300 w. Col Guard—Oct. 26, 1900. No. 37525 A.

Coke Oven Gas.

See Gas Engineering.

Coking.

The New Klondike Coking Field, Pennsylvania. William Gilbert Irwin. Brief account of one of the most important new coke regions. 700 w. Eng & Min Jour—Nov. 3, 1900. No. 37466.

Fuel.

Brown Coal as Fuel. S. Linderoth. Information concerning the origin, varieties, structure, and heating value. 1200 w. Brick—Nov. 1, 1900. No. 37520.

The Fuel Problem of China and the Far East. F. Lynwood Garrison. Information concerning the coal fields, the imports of coal, cost, consumption, etc., and the relation of other countries. 2800 w. Ir Age—Nov. 8, 1900. No. 37572.

Illinois.

Coal Mines at Streator. A. Dinsmore. An interesting illustrated description of the important coal fields and mines in La Salle County, Illinois. 2300 w. Mines & Min—Nov., 1900. No. 37408 C.

India.

An Indian Colliery and Its Miners. Henry M. Cadell. Notes on a visit to the

Karharbari colliery in Lower Bengal, 206 miles northwest from Calcutta. 3500 w. Trans of Min Inst of Scotland—June 9, 1900. No. 37654 D.

Paris Exhibition.

Bethune Colliery at the Paris Exhibition. An illustrated account of the exhibit of this colliery, with a review of its history. 3300 w. Col Guard—Nov. 9, 1900. No. 37709 A.

Lens Collieries at the Paris Exhibition. An account of the exhibit made by one of the most important French collieries, showing the appliances used and methods of working. 4000 w. Col Guard—Nov. 16, 1900. No. 37903 A.

Loire Collieries at the Paris Exhibition. Describes the exhibits of these collieries. 2800 w. Col Guard—Oct. 26, 1900. No. 37526 A.

Production.

The Question of Coal (Zur Kohlenfrage). A review of the question of coal consumption and production, with especial reference to Germany. Glückauf—Oct. 27, 1900. No. 37827 B.

Review.

Annals of Coal Mining and the Coal Trade. Robert L. Galloway. The present article reviews the period from 1836 to 1850, in England. 3500 w. Col Guard—Oct. 26, 1900. No. 37527 A.

Sakhalin.

The Coal Mines of the Island of Sakhalin (Der Steinkohlenbergbau auf der Insel Sachalin). F. F. Kleye. An account of the important developments of coal in the island of Sakhalin in the sea of Okhotsk at the mouth of the Amoor. 3000 w. Oesterr Zeitschr f Berg u Hüttenwesen—Nov. 10, 1900. No. 37-825 B.

United Kingdom.

The Output, Value and Distribution of Coal During 1899. Information from the General Report dealing with the output and value of the minerals and metals of the United Kingdom. 3300 w. Col Guard—Nov. 9, 1900. No. 37710 A.

COPPER.

Idaho.

The Deepest Mine in Idaho. Describes the Ramshorn mine of Bayhorse, in Custer County, the deepest and best developed copper-silver mine in the State. 4000 w. Mines & Min—Nov., 1900. No. 37413 C.

Lake Superior.

Lake Superior Copper Mining. Horace J. Stevens. Facts in regard to the enormous production of the region and the large returns in dividends. 2200 w. Mines & Min—Nov., 1900. No. 37411 C.

New Mexico.

The Santa Rita Copper Mines, New Mexico. W. C. Potter. Brief historical account, with illustrations. 500 w. Eng & Min Jour—Nov. 17, 1900. No. 37724.

Separation.

The Volumetric Estimation of Copper as the Oxalate, with Separation from Cadmium, Arsenic, Tin and Zinc. Charles A. Peters. Shows that moderate amounts of copper may be determined quantitatively as the oxalate by precipitation with oxalic acid and titration of the precipitate by potassium permanganate, and also that moderate amounts may be separated from other metals in the presence of nitric acid, by the addition of oxalic acid. 2500 w. Am Jour of Sci—Nov., 1900. No. 37451 D.

GOLD AND SILVER.

Alaska.

Some Notes on Alaska. W. M. Courtis. Observations made on a recent trip in the Ketchikan district and as far as Bennett Lake. 1000 w. Eng & Min Jour—Nov. 10, 1900. No. 37598.

Cement Gravels.

Successful Working of Cement Gravels. G. E. Bailey. Concerning the difficulty in extracting the gold from the "blue gravels," and the success recently attained. Ill. 1300 w. Min & Sci Pr—Oct. 27, 1900. No. 37464.

Fissure-Veins.

Metasomatic Processes in Fissure-Veins. Waldemar Lindgren. The object of this review is to collect data relating to the alteration of rocks near or between fissures; to indicate the principal active processes; classify the veins, and give conclusions. Ill. 37500 w. Trans Am Inst of Min Engs—Feb., 1900. No. 37627 D.

Free Milling.

Free Gold Milling. W. Muir Edwards. Read before the Applied Science Soc. of McGill Univ. Describes the process from the ore to the bar. 4300 w. Can Engr—Nov., 1900. No. 37631.

Gold Fields.

History of the Southern Appalachian Gold Field. Theo. F. Van Wagenen. Ill. 1400 w. Min Rept—Nov. 8, 1900. No. 37634.

Hydraulic Mining.

Centrifugal Sluicing. A. J. Bensusan. From the *Jour. of the N. S. W. Chamber of Mines.* Describes this process of mining gold from auriferous gravel, giving information concerning work done. 3300 w. Can Min Rev—Oct. 31, 1900. No. 37-437 B.

Leadville.

The "Down Town" mines of Leadville. Arthur Lakes. An illustrated account of

their development and the changing of Leadville from a silver to a gold mining camp. 4000 w. Mines & Min—Nov., 1900. No. 37409 C.

Quartz Mining.

Quartz Mining at Sarela, Central Siberia. An account of a visit to this locality and a favorable report of conditions of labor and mining prospects. 1300 w. U. S. Cons Repts, No. 893—Nov. 22, 1900. No. 37735 D.

Smelting.

Pyritic Smelting in the Black Hills. Franklin R. Carpenter. An account of experimental work. 4800 w. Trans Am Inst of Min Engs—Aug., 1900. No. 37626 D.

Telluride-Ores.

The Telluride-Ores of Cripple Creek and Kalgoorlie. T. A. Rickard. Describes these ores and those associated, their treatment, etc. 3500 w. Trans Am Inst of Min Engs—Aug., 1900. No. 37623 D.

IRON AND STEEL.

Blowing Engines.

Blowing Engines. William E. Snyder. Historical sketch of blowing machines used for iron smelting and for the Bessemer process. Ill. 10000 w. Pro Engrs' Soc of W Penna—Sept., 1900. No. 37912 D.

British Columbia.

The Iron Ores of British Columbia. H. Mortimer Lamb. A fully illustrated account of the development of a new industry on the Pacific coast of America. 3000 w. Engineering Magazine—Dec., 1900. No. 37864 B.

Deterioration.

Influence of Copper in Retarding Corrosion of Soft Steel and Wrought Iron. F. H. Williams. Brief report of investigations made to find out what influence the presence of copper might have. 500 w. Pro Engs' Soc of W Penna—Sept., 1900. No. 37913 D.

Early Enterprises.

Early Iron Enterprises in Cambria, Somerset, Westmoreland and Indiana counties, Pa. James M. Swank. Historical summary, giving facts of interest. 500 w. Am Mfr & Ir Wld—Nov. 1, 1900. No. 37478.

India.

The Iron Ores of India. An interesting article on the mineral industries of India, their early success, and the causes of the present unimportant position of the country in the production of this metal. 4700 w. Col Guard—Nov. 16, 1900. No. 37900 A.

Iron Prospects.

The Revival and Reaction in Iron. Archer Brown, in *The Forum.* History of the sudden rise and fall of the past two years, and the outlook for the future. 4400 w. Am Mfr & Ir Wld—Nov. 8, 1900. No. 37628.

Iron Trade.

The Iron Trade of the Leading Countries of the World. Statistical and other information relating to the recent development of the iron and steel trade of the world. The present article is a general survey of the existing situation. 4500 w. Ir & Coal Trds Rev—Nov. 16, 1900. Serial. 1st part. No. 37793 A.

Mesabi.

The Mesabi Range. Cyril Brackenburg. An illustrated description of the ore and also of the open pit, the caving and the milling methods of mining. 3000 w. Mines & Min—Nov., 1900. No. 37410 C.

Norway.

Norway as an Iron-Producing Country. (Norwegen als Eisen Erzeugendes Land). Otto Vogel. A review of the iron production of Norway, and a discussion of its future development. Serial. Part I. 4000 w. Stahl und Eisen—Nov. 15, 1900. No. 37854 D.

Progress.

The Progress of the Iron and Steel Industries. Leyshon D. Thomas. Extracts from a presidential address delivered before the So. Staffordshire Ir. & Steel Inst. 4500 w. Col Guard—Nov. 2, 1900. No. 37616 A.

Steel.

See Mechanical Engineering, Materials.

Steel Exports.

Steel Rail Prices and Freight Rates on Steel Exports. Editorial, discussing the present situation between the steel-makers and railway companies in the United States. 1800 w. Eng News—Oct. 18, 1900. No. 37544.

Steel Plant.

The Dominion Iron & Steel Company, Limited. Illustrated detailed description of this plant at Sydney, C. B., and related matter. 4800 w. Ir Age—Nov. 8, 1900. No. 37574.

MINING.

Accidents.

Fatal Accidents in Coal Mining in North America. F. L. Hoffman. Reviews the period 1890-1899 for the United States and Canada, with comments. 1300 w. Eng & Min Jour—Nov. 24, 1900. No. 37752.

Boring.

New Systems of Boring (Ueber Einige Neue Bohrsysteme). W. Wolski. The

method includes the use of a reciprocating hydraulic motor operating the tool and capable of being lowered with the latter down the bore hole. 3000 w. Glückauf—Oct. 27, 1900. No. 37826 B.

Explosion.

The Explosion at the Red-Ash Colliery, Fayette County, West Virginia. W. N. Page. Gives results of an examination to determine the extent and cause of the explosion that occurred March 6, 1900, destroying much property and many lives. 3500 w. Trans Am Inst of Min Engs—Aug., 1900. No. 37622 D.

Ignition.

The Ignition of Mining Blasts by Accumulators (Accumulator-Minenzündung). J. von Lauer. A description of the use of the accumulator for igniting blasts in gaseous mines with a minimum of danger of firedamp explosions. 1200 w. 1 plate. Oesterr Zeitschr f Berg u Hüttenwesen—Oct. 20, 1900. No. 37823 B.

Lining.

Lining the Mine Gallery at Gardanne. G. Leugny, in *La Revue Technique.* Illustrates and describes the work, materials used, etc. 700 w. Col Guard—Nov. 2, 1900. No. 37614 A.

Measuring Drift.

A Method for Obtaining the Volume of Small Drifts and Working-Places, Where It Is Impossible to Use a Transit. C. S. Herzig. States the conditions and describes method. 1200 w. Trans Am Inst of Min Engs—Aug., 1900. No. 37624 D.

Mining Law.

The Principles of Mining Law. Charles J. Alvord. Abstract of a paper read before the Inst. of Min. & Met., in London. Reviews briefly the law of the more important countries of the world. 3200 w. Eng & Min Jour—Nov. 17, 1900. No. 37725.

Mining Plant.

See Electrical Engineering, Power Applications.

Props.

Tapered Props and Bars. W. Hutton Hepplewhite. Read at Derby meeting of the Inst. of Min. Engs. Illustrated description of patent tapered pit props and bars, with a statement of the advantages claimed for them. 700 w. Col Guard—Nov. 16, 1900. No. 37901 A.

Quarrying.

Quarrying by the Helicoidal Wire. N. Pellati. From a paper prepared for the Congress at Paris. Explains this method of cutting and its advantages. 1000 w. Stone—Oct., 1900. No. 37560.

Safety Appliances.

On Safety Appliances and Precautions Necessary in Mines. J. R. Godfrey. Read before the Aust. Inst. of Min. Engs. Reviews the precautions which should be adopted to minimize the dangerous factors. Ill. 6500 w. Can Min Rev—Oct. 31, 1900. Serial. 1st part. No. 37438 B.

Shafts.

Deepening the No. 2 Shaft of the Rheinelbe and Alma Colliery. Illustrates and describes work attended with exceptional difficulty, as other uses of the shaft could not be interrupted. 2800 w. Ir & Coal Trds Rev—Nov. 9, 1900. No. 37712 A.

Headgear and Winding Engines for Deep Shafts. Léon Poussigue. From a paper read at the Paris Congress. Illustrated discussion of the winding engine, headgear, detaching hooks, etc. 3500 w. Col Guard—Nov. 2, 1900. No. 37613 A.

Survey.

A Mining Survey. J. F. Wilkinson. Description of a survey made in June, 1890, for the San Francisco shaft of the New Almaden quicksilver mines, which required great accuracy. 1800 w. Trans Am Inst of Min Engs—Aug., 1890. No. 37625 D.

Wire Rope.

Notes on Wire Rope (Einiges über Seildraht und Drahtseile). J. Divis. With especial reference to the manufacture and character of ropes for mining service. Serial. Part I. 4000 w. Oesterr Zeitschr f Berg u Hüttenwesen—Nov. 3, 1900. No. 37824 B.

MISCELLANY.

Analysis.

The Analysis of Uranium and Vanadium Ores. Oliver P. Fritchie. Directions for the determination. 800 w. Eng & Min Jour—Nov. 10, 1900. No. 37597.

High Temperatures.

Alumiothermic (L'Aluminothermic). L. Guillet. A discussion of the application of the Goldschmidt process of combustion of aluminum for the reduction of metals to the pure state. 3000 w. Génie Civil—Oct. 20, 1900. No. 37801 D.

Oil Fields.

The Oil Fields of Kern County, Cal. H. G. Parsons. Illustrated account of the Kern River district, reporting the development, quality of oil, value, and records of various companies. 4600 w. Min & Sci Pr—Oct. 27, 1900. No. 37463.

Ores.

Ore Buying. F. Danvers Power. Abstract of a paper read before the N. S. W. Chamber of Mines. Points on estimating, assaying, and methods in common prac-

tice. 1200 w. Ir & Coal Trds Rev—Nov. 2, 1900. No. 37620 A.

Platinum.

The Working of Platinum. John G. Niederer. Interesting facts regarding the peculiarities of this valuable metal. 900 w. Am Mach—Nov. 15, 1900. No. 37647.

Potassium Salt.

The Bleicherode-Sonders-hausen Potassium Salt Deposit. E. C. Mackay-Heriot. A description of this salt formation, giving profile near Munchen-Lohre, Germany. 900 w. Eng & Min Jour—Nov. 3, 1900. No. 37467.

Siberia.

The Future Possibilities of Siberia. On the resources of the country, especially its mineral deposits and methods of mining, and the effect the development will soon show. 3000 w. U. S. Cons Repts, No. 880—Nov. 7, 1900. No. 37534 D.

Zinc.

Some Changes in the American Zinc Industry. Editorial discussing the advantage gained by the natural-gas smelters in Kansas, and other matters of interest. 1100 w. Eng & Min Jour—Nov. 10, 1900. No. 37596.

RAILWAY AFFAIRS

CONDUCTING TRANSPORTATION.

Accidents.

The Explosion of a Locomotive at Westerfield. An illustrated account of an unusual explosion on an English railway, and a study of the cause. 1300 w. Engr, Lond—Oct. 26, 1900. No. 37532 A.

Train Accidents in the United States in October. Detailed list and classified summary. 5000 w. R R Gaz—Nov. 23, 1900. No. 37948.

Checks.

The Elimination of the Brass Check. Abstract of paper by M. G. Carrel, presented at meeting of the Genl. Pass. Agts. Assn. An argument in favor of the substitution of the card for the brass check, and showing its advantages. 1400 w. Ry Age—Nov. 9, 1900. No. 37632.

Delays.

Train Delays. Condensed report on train delays, their causes, cost, responsibility for and remedies, presented at the Oct. meeting of the Pacific Coast Ry. Club. 3000 w. R R Gaz—Nov. 23, 1900. Serial. 1st part. No. 37750.

Fast Runs.

Fast Running on the Northern France. Report of a run from Arras to Paris. 450 w. R R Gaz—Nov. 16, 1900. No. 37671.

The Fast Camden-Atlantic City Trains. Facts and particulars concerning trains run by the Pennsylvania R. R. and the Philadelphia & Reading R. R. 3000 w. R R Gaz—Nov. 2, 1900. No. 37491.

Organization.

The Organization of a Great Railroad. Gives the organization of the Operating Department of the Southern Ry. 1400 w. R R Gaz—Nov. 9, 1900. No. 37603.

MOTIVE POWER AND EQUIPMENT.

Coaches.

New Coaches for "Black Diamond" Express. Plan, illustrations and description of new cars for the Lehigh Valley R. R. 500 w. R R Car Jour—Nov., 1900. No. 37621.

Diamond Stacks.

The Passing of the Diamond Stack. Thomas P. Whelan. On the advantages of the old diamond stack as compared with straight stacks, and the reason of the change. 1000 w. Loc Engng—Nov., 1900. No. 37422 C.

Draft Gear.

Draft Gear and Couplers for Heavy Service. A letter from George Westinghouse, with editorial discussion of the subject. 1700 w. R R Gaz—Nov. 16, 1900. No. 37672.

Draft Gear—The Most Important Present Question in Car Construction. Report of trials of the Westinghouse friction draft gear, and the results. 1200 w. Am Engr & R R Jour—Nov., 1900. No. 37475 C.

The Drop Test as a Means of Showing Relative Strength of Draft Gears. R. P. C. Sanderson. Extracts from a paper before the Western Ry. Club. Gives an account of the A., T. & S. F. draft-gear drop tests, and points related. 1600 w. R R Gaz—Nov. 23, 1900. No. 37749.

Fireboxes.

Large Locomotive Fireboxes. A. Bement. Compares an engine of ten years ago with one of recent date, and discusses the influence on combustion. 1500 w. Am Engr & R R Jour—Nov., 1900. No. 37473 C.

Fuel.

Liquid Fuel for Locomotives. Extracts from a paper by James Holden, presented at the Paris Congress. 3000 w. R R Gaz—Nov. 2, 1900. No. 37492.

Grates.

Emancipation of the Grates. Editorial discussion of the importance of recent

changes in grate area. 1400 w. Am Engr & R R Jour—Nov., 1900. No. 37474 C.

Hopper Rigging.

An Inexpensive Hopper Rigging. Brief illustrated description of a simple and effective hopper rigging for use on double-bottom coal cars on the Central Railroad of N. Jersey. 500 w. Am Engr & R R Jour—Nov., 1900. No. 37477 C.

Locomotives.

Brooks Chautauqua Type Locomotive, B. C. R. & N. Ry. Illustrations, leading dimensions, and general particulars. 1500 w. Ry & Engng Rev—Nov. 24, 1900. No. 37920.

Four-Cylinder Compound Locomotives (De Glehn Type). Illustration of this type, with views of prominent railroad men, and notes giving results of work done by these engines. 2500 w. Transport—Nov. 9, 1900. No. 37705 A.

High-Speed Locomotive for International Express Service; Schneider & Co. Exhibit, Paris Exposition. An illustrated description of an interesting machine with many novel features. 1800 w. Eng News—Oct. 18, 1900. No. 37541.

Locomotive and Tender with Two Coupled Axles (Locomotives-Tenders à Deux Essiux Accouplés). F. Barbier. Description of the simple coupled tank-locomotive exhibited at Paris by Krauss, of Munich. 1800 w. 1 plate. Génie Civil—Oct. 27, 1900. No. 37809 D.

Locomotives for Russian State Railways. Particulars, with illustrations. 500 w. Engng—Nov. 9, 1900. No. 37693 A.

Locomotives for the New Zealand Government Railways. Illustrated description of the two most recent types adopted for the main-line service. 700 w. Engr, Lond—Nov. 9, 1900. No. 37697 A.

New Locomotives for the "Atlantic City Flyers." An account of this rapid service and the competition between the Pennsylvania R. R. and the Philadelphia & Reading R. R., with illustrated description of the latest locomotives built for the last named road. 2500 w. Engr, Lond—Nov. 9, 1900. No. 37696 A.

New York Central's Latest Express Engine. Illustrates and describes an eight-wheel locomotive for fast express service. 250 w. Loc Engng—Nov., 1900. No. 37420 C.

Notes on English and French Compound Locomotives. Charles Rous-Marten. Paper read before the Soc. of Engs., England. A review of the merits and demerits of compounding from the viewpoint of its practical value in regular service, with conclusions. 1700 w. Transport—Nov. 9, 1900. Serial. 1st part. No. 37704 A.

Performance of "Northwestern" Type Locomotives. Profile of the C. & N. W. Ry., with record showing sustained high horse-power for a run of 138 miles, and indicator cards corresponding, with comments. 1300 w. Am Engr & R R Jour—Nov., 1900. No. 37468 C.

Simon's Express Ten Wheeler. Illustrates and describes a powerful ten-wheel passenger engine. 350 w. Loc Engng—Nov., 1900. No. 37421 C.

Some New Locomotives of the Plant System. Specifications and brief description, with illustrations. 500 w. R R Gaz—Nov. 2, 1900. No. 37495.

Superheaters and Steam Jackets for Locomotives. Drawings and notes concerning an experiment being tried in England by the Lancashire & Yorkshire Ry. 400 w. Am Engr & R R Jour—Nov., 1900. No. 37476 C.

The Distribution of Steam in the Cylinders of Compound Locomotives (La Distribution de la Vapeur dans les Cylindres des Locomotives Compound). A mathematical analysis of the action of the valve gear in the distribution of steam in compound locomotives, with numerous examples. 4500 w. Revue Technique—Nov. 10, 1900. No. 37843 D.

The Growing Diversity in Locomotive Designs. Reviews the efforts made toward uniformity, and the causes that brought the movement into disfavor. 1000 w. Loc Engng—Nov., 1900. No. 37423 C.

Twelve-Wheel Wide-Firebox Freight Locomotive. Illustrates and describes a locomotive designed to burn bituminous slack in a fire-box extending over the rear driving wheels, the construction being such as to bring the engineer and fireman together in the same cab. 500 w. Am Engr & R R Jour—Nov., 1900. No. 37471 C.

Two-Cylinder Compound Locomotive for the North-Eastern Railway of Switzerland. Illustrated description. 600 w. Engng—Nov. 16, 1900. No. 37905 A.

Wide Fire-box Freight Locomotives for the Chicago & Eastern Illinois. Illustrates and describes one of the wide fire-box, compound, 12-wheel freight locomotives which will burn bituminous coal. 600 w. R R Gaz—Nov. 16, 1900. No. 37670.

See Street and Electric Tramways.

Motive Power.

What Motive Power Officers Consider Important. Report of interviews with progressive men. 2000 w. Am Engr & R R Jour—Nov., 1900. Serial. 1st part. No. 37469 C.

Railway Wagons.

Capacity of Railway Wagons as Affecting Cost of Transport. J. D. Twinberrow. Discusses the possible saving by employing vehicles of greater earning capacity, and the difficulties that stand in

the way. Ill. 6300 w. Inst of Mech Engs—Nov. 16, 1900. No. 37792 D.

Sleeping Cars.

Pullman Sleeping Cars for the Midland Railway. Illustrated description of fine cars for the Scotch service. All berths are on a level, the upper berths having been abandoned. 500 w. Engng—Nov. 9, 1900. No. 37692 A.

Smokeboxes.

Some Modern Locomotive Smokeboxes: Their Blast Pipes and Fittings. G. Willans. Illustrated description of various modern arrangements. 1400 w. Prac Engr—Nov. 9, 1900. No. 37702 A.

Smokeless Combustion.

Smokeless Combustion in Locomotive Fireboxes. A. Bement. Abstract of a paper presented before the W. Ry. Club. Treats of details of the combustion process. 1200 w. Eng News—Oct. 18, 1900. No. 37547.

Steel Cars.

Steel Flat Cars, 100,000 Pounds Capacity. Drawings and description of cars for the N. Y. C. & H. R. R. R. 400 w. Am Engr & R R Jour—Nov., 1900. No. 37470 C.

Track Tank.

Track Tank Water Scoop. Illustrates and describes a design worked out by H. F. Ball for the L. S. & M. S. Ry. for use on fast passenger locomotives and also in freight equipment. The tests give a very satisfactory performance. 900 w. Am Engr & R R Jour—Nov., 1900. No. 37472 C.

Train Lighting.

The Electric Lighting of Railway Trains (L'Eclairage Electrique des Voitures de Chemin de Fer). A description of the method of the Compagnie Générale Electrique, using a dynamo driven by the axle, and operated in connection with an accumulator. 3500 w. Revue Technique —Oct. 25, 1900. No. 37811 D.

Valves.

Piston Valves. Wilson Worsdell. Illustrates and describes valves used by the North Eastern Railway of England. 900 w. R R Gaz—Nov. 12, 1900. No. 37493.

Wheels.

Cast-Iron Car Wheels. G. W. Beebe. Abstract of a paper presented before the W. Ry Club. Discusses the manufacture and testing of cast-iron wheels, with a comparative record of tests made by the writer, and recommendations which he thinks would lead to better results. Ill. 2200 w. Eng News—Oct. 18, 1900. No. 37545.

Wrecking.

Wrecking Outfit, Pennsylvania Lines West. An illustrated account of a very complete wrecking outfit of the Pennsylvania Lines West, with editorial. 2700 w. Ry & Engng Rev—Nov. 3, 1900. No. 37567.

NEW PROJECTS.

Arkansas.

New Railroad Work in Arkansas. Information concerning work building and projected. 1700 w. R R Gaz—Nov. 9, 1900. No. 37607.

Boston & Albany.

The Absorption of the Boston & Albany by the New York Central. Editorial concerning the lease for 99 years about to be ratified. 1300 w. R R Gaz—Nov. 2, 1900. No. 37497.

China.

The German Railway in Shantung, China. H. L. Geissel. Brief description of the line now in process of construction. 600 w. Eng News—Nov. 29, 1900. No. 37936.

Mexico.

Railroad Building in Mexico. A review of roads building or under contract showing activity. 1800 w. R R Gaz—Nov. 9, 1900. No. 37606.

Scotland.

The Connell Ferry and Ballachulish Railway. An account of a new railway in Scotland that will open a country of great beauty, as well as develop the resources of this region. 3000 w. Engr, Lond—Nov. 16, 1900. No. 37796 A.

Siberia.

Siberian Competition. An editorial discussion of Siberian conditions, with extracts from a series of articles by Dr. Kurt Widenfeld, in the *Archiv. für Eisenbahnwesen.* 2000 w. R R Gaz—Nov. 2, 1900. No. 37496.

PERMANENT WAY AND BUILDINGS.

Copenhagen.

The International Competition for the Rebuilding of the Passenger Station at Copenhagen (Der Internationale Wettbewerb für den Umbau des Personenbahnhofs in Kopenhagen). With plans of the prize-winning designs and a discussion of the proposed improvements. 1800 w. Schweizerische Bauzeitung—Oct. 20, 1900. No. 37821 B.

Grades.

Investigation as to Virtual Grades, Canadian Pacific Ry. A. C. Dennis. Diagrams, with explanation of their use. 1000 w. Eng News—Nov. 22, 1900. No. 37926.

Icing Plant.

New Icing Plant of the "Burlington Route" at Hannibal, Mo. Illustrated de-

scription. 450 w. R R Gaz—Nov. 23, 1900. No. 37745.

Rail Joints.

Broken and Square Rail Joints for Railway Track. Expressions of opinion concerning the use of the two methods, and the reasons for and against them. 1400 w. Eng News—Nov. 15, 1900. No. 37685.

Signals.

Automatic Electric Block Signals for Railways (Elektrisch Selbstthätige Block Signale für Eisenbahnen). L. Kohlfürst. Advocating the introduction of automatic signals, and describing the Sacek system. Serial. Part I. Elektrotech Zeitschr—Nov. 8, 1900. No. 37839 B.

Automatic Signal Locations. C. C. Rosenberg. Condensed paper read before Ry. Sig. Club, at St. Louis. Suggestions concerning methods of locating, and things to be avoided. 1200 w. R R Gaz—Nov. 2, 1900. No. 37494.

Some Questions About Progress and Uniformity in Signaling. B. B. Adams. Extracts from a paper read before the Ry. Sig. Club. 1000 w. R R Gaz—Nov. 9, 1900. No. 37604.

Station.

Passenger Station of the Southern Railway at Richmond. Illustrated description. 450 w. R R Gaz—Nov. 9, 1900. No. 37605.

Switches.

Split Switches. Extracts from a report presented before the Roadmasters' Assn. of America. 900 w. Ry & Engng Rev—Nov. 24, 1900. No. 37921.

Terminal.

Locomotive Terminal of the French Eastern Railway at Noisy-le-Sec. Brief illustrated account of these buildings in the suburbs of Paris and their appointments. 1200 w. Ry & Engng Rev—Nov. 3, 1900. No. 37568.

The Terminal Improvements of the Chesapeake & Ohio Ry., at Richmond, Va. Illustrated description of work, including a long line of viaduct, and a new union station and train shed. 2200 w. Eng News—Nov. 29, 1900. No. 37937.

Ties.

The Preservation of Ties on the Southern Pacific Ry. Particulars as to the preservative treatment and the renewals of treated ties. 2500 w. Eng News—Oct. 25, 1900. No. 37551.

Transition Curves.

Transition Curves. J. H. Lory. Gives the writer's conclusions in spiraling track and the system used. 1200 w. Jour W Soc of Engs—Oct., 1900. No. 37418 D.

TRAFFIC.

Rates.

A Railway Freight Rate of 2 Mills Per Ton-Mile. Editorial discussion of the remarkable low rates. 1800 w. Eng News—Nov. 8, 1900. No. 37599.

The New German Railway Rates for the Carriage of English Coal Imports. An explanation of the condition of affairs at the present time. 1000 w. Col Guard—Oct. 26, 1900. No. 37528 A.

STREET AND ELECTRIC TRAMWAYS

Accounting.

The Routine of a Railway, Electric and Gas Lighting Company. C. O. Simpson. Read at Kansas City Convention. Points relating to office methods. 2500 w. St Ry Jour—Nov. 3, 1900. No. 37490 D.

Car Bodies.

Painting, Repainting and Maintenance of Street Car Bodies. F. T. C. Brydges. Read at Kansas City Convention. A discussion of methods and report of cost. 2200 w. St Ry Jour—Nov. 3, 1900. No. 37489 D.

Car Heating.

Heating of Tramway and Light Railway Cars. M. C. de Burlet. Abstract of paper read at the Congress at Paris. Considers methods of heating. 1200 w. Tram & Ry Wld—Oct. 11, 1900. No. 37445 A.

Carlisle, Eng.

The City of Carlisle Electric Tramways. Illustrated detailed description of overhead construction system. 1600 w. Tram & Ry Wld—Oct. 11, 1900. No. 37442 A.

"Centrifugal" Railway.

A "Centrifugal" Railway for Pleasure Resorts. M. F. Brown. A brief illustrated description of a railway built at Rivers Beach, Mass. 1000 w. Eng News—Nov. 15, 1900. No. 37690.

Compressed Air.

Compressed Air for Street Railway Operation. H. D. Cooke. Read at meeting of N. Y. State St. Ry. Assn. Briefly describes the construction and operation of the air car. 2500 w. Compressed Air—Nov., 1900. No. 37588.

Compressed Air Traction in New York

City. A summary of the recent developments of this mode of traction in New York City. Ill. 2500 w. R R Gaz—Nov. 23, 1900. No. 37746.

Compressed Air Locomotives. H. K. Myers. Considers principles governing their construction, and gives some of the reasons why they are often preferred in mines. Ill. 2500 w. Mines & Min—Nov., 1900. No. 37414 C.

Report on the New Hardie Air Motor Cars Now in Use on the 28th and 29th Street Line, New York City. W. L. Hoffecker. Letter giving favorable report of inspection. 1200 w. Compressed Air—Nov., 1900. No. 37589.

Consolidation.

Consolidation of Street Railways and Its Effect Upon the Public. Daniel B. Holmes. Read at Kansas City Convention. Shows that such consolidation brings benefits to the public as well as to the companies. 2000 w. St Ry Jour—Nov. 3, 1900. No. 37487 D.

Contact System.

Electro-Magnetic Contact System for Tramways (Elektromagnetisches Kontaktsystem für Elektrische Bahnen). J. P. Doflein. A description of the Stobrawa system, used by the Helios Company. 2500 w. Elektrotech Zeitschr—Nov. 8, 1900. No. 37838 B.

The Schuckert Contact System of Electric Traction. Illustrated detailed description of the improved system as introduced in Munich. 1900 w. Elec Engr, Lond—Nov. 16, 1900. No. 37786 A.

Cross-Country System.

The Exeter, Hampton & Amesbury Street Railway. C. B. Fairchild. Illustrated detailed description of interesting lines through a very attractive region. 3700 w. St Ry Rev—Nov. 15, 1900. No. 37713 C.

Distribution.

Comparisons of the Various Systems of Electrical Distribution for Street Railways. C. F. Bancroft. Read at Kansas City Convention of Am. St. Ry. Assn. Discusses the six systems at present in use, and the need of selecting the system best suited to the conditions. 3000 w. St. Ry Jour—Nov. 3, 1900. No. 37488 D.

Double Trucks.

Double Truck Cars: How to Equip Them to Obtain Maximum Efficiency Under Varying Conditions. N. H. Heft. Discusses trucks, electric motors, and double truck car body and equipment. Followed by general discussion. 8800 w. St Ry Rev—Nov. 15, 1900. No. 37715 C.

Electrolysis.

Electrolysis in Reading, Pa. Illustrated extracts from a report by A. A. Knudson, on an electrical survey of the water mains in Reading, the interlacing of street tracks introducing some special features. Also editorial note on the danger of stalling cars at railroad crossings. 4500 w. Eng Rec—Nov. 10, 1900. No. 37585.

Funicular Road.

The Malberg Railway at Ems (Die Malbergbahn bei Ems). R. Schaar. Illustrated account of this double cable road, operating up grades of 54 per cent., on the Malberg, near the watering place of Ems. 1800 w. Ill. Zeitschr f Klein u Strassenbahnen—Nov. 1, 1900. No. 37842 D.

Locomotives.

Accumulator-Driven Locomotives for Workshops (Ueber Fabrik locomotiven mit Accumulatorenbetrieb). Max Büttner. Illustrating and describing a number of electric locomotives used in manufacturing establishments in Germany, and showing the advantages of accumulators for such service. 2500 w. Stahl und Eisen—Nov. 1, 1900. No. 37853 D.

Standard Gauge Electric Locomotive (Elektrische Vollbahn-Locomotive). Illustrated account of the powerful electric locomotives for standard gauge service, built by the Allgemeine Elektricitäts Gesellschaft, of Berlin. 3000 w. Mitt d Ver f d Förd d Local u Strassenbahnwesens—Oct., 1900. No. 37851 D.

London Railway.

The Central London Railway. An illustrated account of this underground railway and its equipment. 7400 w. Tram & Ry Wld—Nov. 8, 1900. No. 37939 A.

Moulineaux Station.

The Moulineaux Traction Station at Paris. Illustrated description of the largest electrical generating station in France. 1100 w. Tram & Ry Wld—Oct. 11, 1900. No. 37443 A.

Rack Railway.

A Rack Railway on the Island of Sumatra. Illustrated description of a line used almost exclusively for the transportation of bituminous coal. 400 w. Sci Am—Nov. 3, 1900. No. 37427.

Rail Joints.

The Falk Cast-Welded Rail Joint on European Street Railways. Concerning the advantages of the cast-joint over the electrically welded joint, and the use as reported by tramway companies. 800 w. Eng News—Nov. 15, 1900. No. 37684.

Rapid Transit.

Progress of Work on the Rapid Transit Tunnel, New York. Views, showing the plant and method of construction with explanatory notes. 1500 w. Sci Am—Nov. 24, 1900. No. 37740.

NEW BOOKS.

THE STRENGTH OF MATERIALS. By J. A. Ewing, M. A., etc., etc. Cambridge: University Press. A reprint, with many additions and improvements, of Professor Ewing's article on the Strength of Materials in the Ninth Edition of the Encyclopædia Britannica. The work is intended to be used as a text-book in connection with laboratory and drawing office work.

ELEMENTS OF THE MATHEMETICAL THEORY OF ELECTRICITY AND MAGNETISM. By J. J. Thomson, M. A., F. R. S., etc., etc. Second edition. Cambridge: University Press. This revised edition of Professor Thomson's well-known work has the typographical errors of the earlier edition corrected, and passages which experience had shown to offer unusual difficulties to students have been verbally explained at greater length.

WIRELESS TELEGRAPHY AND HERTZIAN WAVES. By S. R. Bottone. London and New York: Whittaker & Co. A small treatise, explaining in simple language, without the use of mathemetical formulæ, the principles on which those phenomena known as electric waves, and their practical application in signalling through space are dependant: together with descriptions of apparatus used in wireless telegraphy.

LECONS D'ELECTROTECHNIQUE GENERALE. Par P. Janet. Paris: Gauthier Villars. This treatise consists practically of the course in electricity of the Ecole Superieure d'Electricite at Paris, and is written by the director of the central laboratory of that institution. An especial feature is the full bibliography of each department of the subject appended to each chapter.

THE RISE AND DEVELOPMENT OF THE LIQUEFACTION OF GASES. By Willett L. Hardin, Ph. D. New York: The Macmillan Company. London: Macmillan & Co., Ltd. A complete history of the development of the methods employed in the liquefaction of gases, written in popular style, with references to the original memoirs of the various investigators.

TEXT BOOK OF THEORETICAL NAVAL ARCHITECTURE. By E. L. Attwood, Assistant Constructor, Royal Navy. London, New York, and Bombay: Longmans, Green & Co. Adapted as a text-book for the theoretical portions of the examinations of the Science and Art Department in Naval Architecture. The methods of computation given are illustrated by many practical examples.

ENGINE TESTS. By George H. Barrus, S. B. New York: D. Van Nostrand Company. A record of the results of more than one hundred feed water tests and other investigations upon various kinds of steam engines conducted by the author, with much useful information concerning the making and interpretation of engine trials.

HEAT AND HEAT ENGINES. By Frederick Remsen Hutton, E. M., Ph. D. New York: John Wiley & Sons. London: Chapman & Hall. Limited. A text book treating of the principles underlying the mechanical engineering of power plants, including heat, fuel, combustion, and the various methods of applying heat and converting it into mechanical energy. The discussions include steam engines, compressed air engines, internal combusion motors, and mechanical refrigeration.

THE LAW OF OPERATIONS PRELIMINARY TO CONSTRUCTION IN ENGINEERING AND ARCHITECTURE. By John Cassan Wait, M. C. E., LL. B. New York: John Wiley & Sons. London: Chapman & Hall, Limited. Supplementing the author's previous work, "Engineering and Architectural Jurisprudence," and dealing with the knowledge of legal matters essential to the most advantageous conduct of the preliminaries of engineering work, such as rights in real property, boundaries, easements, and franchises.

A HAND-BOOK OF THE ELECTRO-MAGNETIC TELEGRAPH. By A. E. Loring. New York: D. Van Nostrand Co. The fourth edition of a convenient little hand-book by a practical telegraph operator, giving useful information regarding instruments, wiring and maintenance, together with hints about learning to become an operator.

ELECTRIC POWER TRANSMISSION. By Louis Bell, Ph. D. Second Edition. Revised and Enlarged. New York: *Electrical World and Engineer*. A second edition of Dr. Bell's well-known treatise, with typographical errors corrected and a discussion of the advances which have been made in the use of high voltages and in long-distance transmission.

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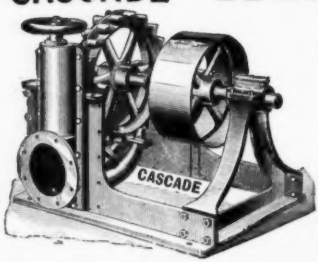

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BORN IN THE MACHINE SHOP

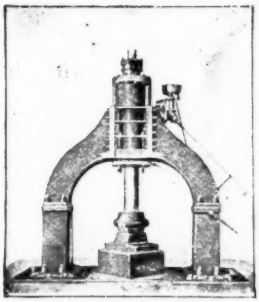
A NOTEWORTHY FACT

IT is a significant fact, worthy of record, that this great Special Number of THE ENGINEERING MAGAZINE really had its birth in the machine-shop.

In 1896 we published a paper entitled "The Destructive Use of Machine Tools"—advocating the radical policy of driving expensive new machinery, night and day, to the last limit of cutting capacity; then tossing it into the scrap-heap, replacing it with new and better types if possible, and in turn employing them in like manner.

The old idea had been to nurse costly new machinery; to give it the most watchful care, never subject it to undue strain, and, by saving it, to make it last as long as possible. But here was the Baldwin Locomotive Works, one of the foremost firms in the world, achieving notable and world-wide success, by acting squarely on the new policy—actually driving all its costly mechanical equipment to the power limit, and doing it all the time!

Naturally enough the publications excited the widest interest, provoked a stream of inquiries from all quarters, and thus began the One Hundred Expert Articles discussing every practical problem of the modern machine-shop, foundry, etc. From that hour the Magazine has been indispensable to machine-shop proprietors, engineers, managers, and superintendents; and the force of its appeal to the interest of such readers may be judged from the titles of our past publications as given in *Section XI., Engineering Publications* of this number.



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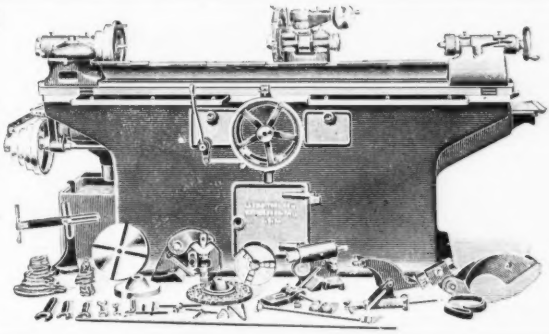

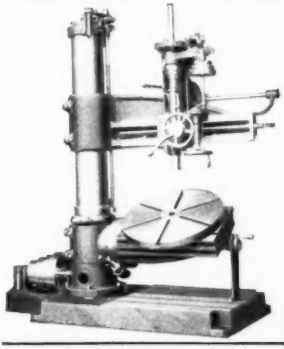

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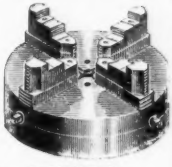

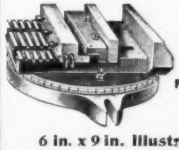

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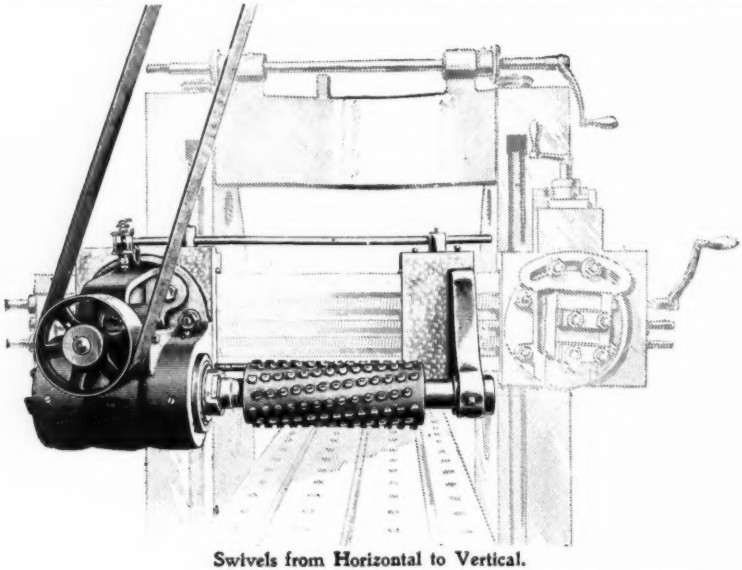
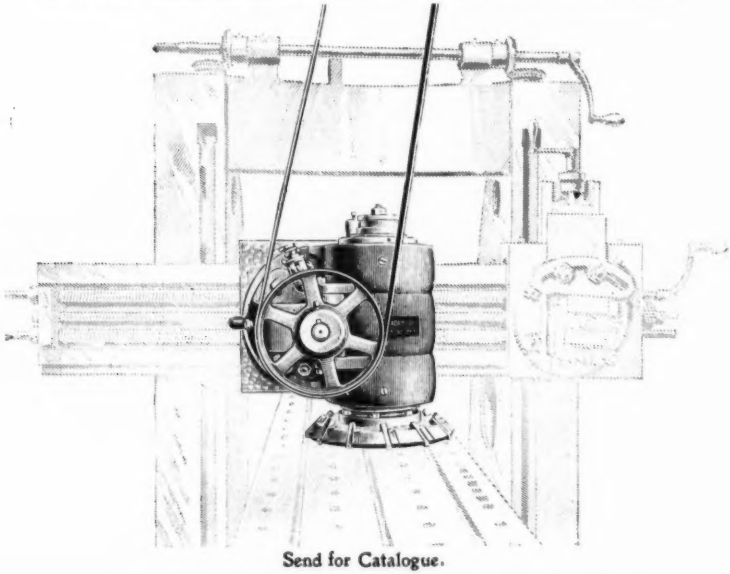


Swivels from Horizontal to Vertical.

Do not plane surfaces that should be milled, or mill surfaces that should be planed



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VARIOUS SIZES OF

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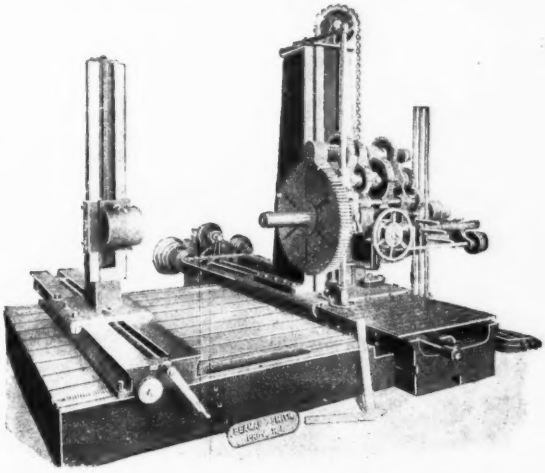

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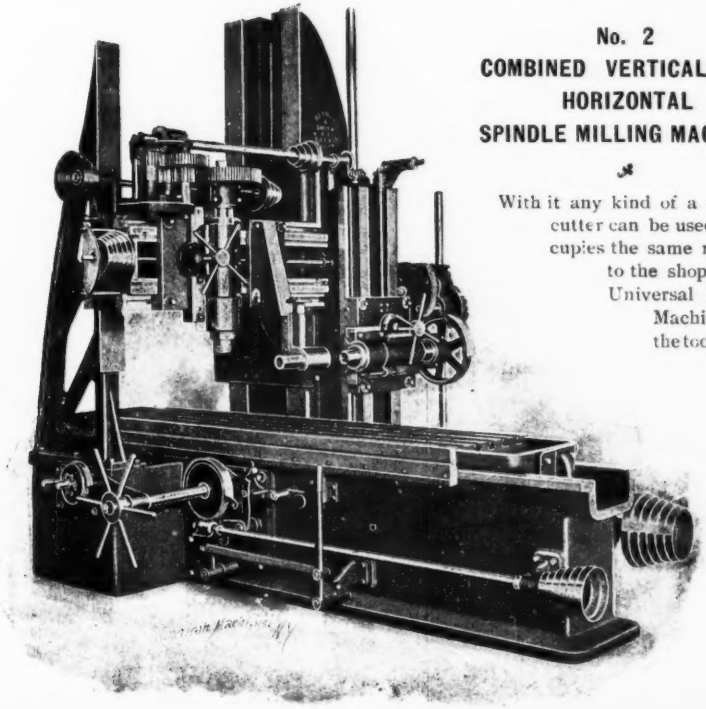

No. 2 COMBINED VERTICAL AND HORIZONTAL SPINDLE MILLING MACHINE.

With it any kind of a milling cutter can be used. Occupies the same relation to the shop as the Universal Milling Machine to the tool room

Milwaukee Universal Milling Machine.

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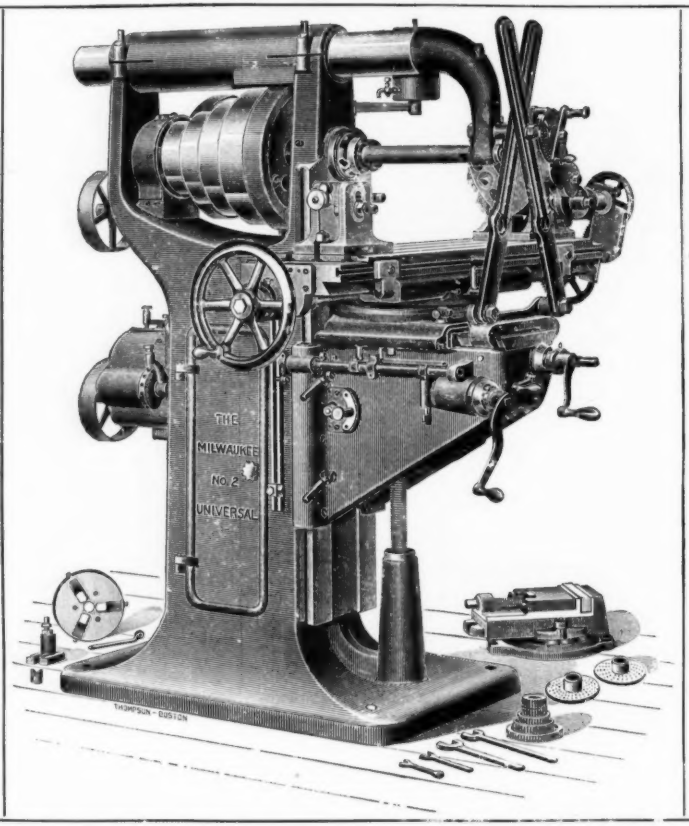

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Automatic Cross Feed, 10 inches. **Vertical Feed, 18 inches.**
Automatic Feeds in all directions.

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is a distinctive feature of "The Cincinnati" Milling Machine.
Specialized manufacture enables us to perfect details.
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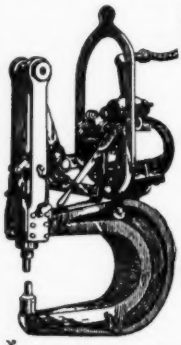

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For Bridge and Structural, Boiler and Tank Work.

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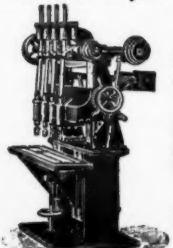

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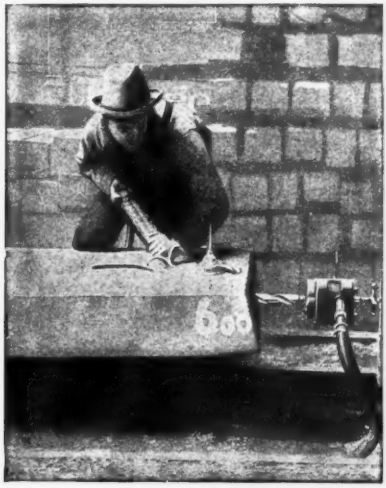

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and can supply you with tools to meet all requirements.

We also make

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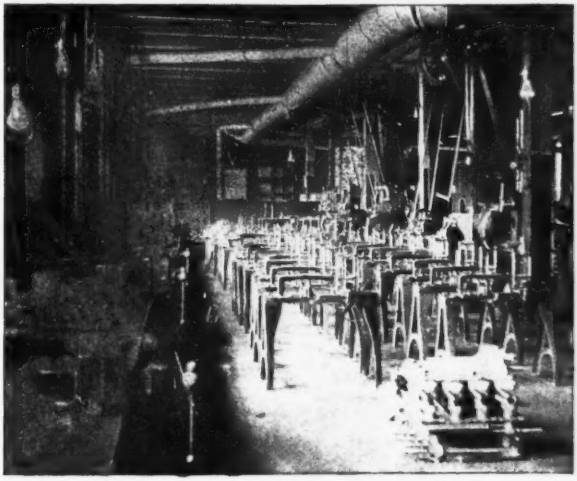

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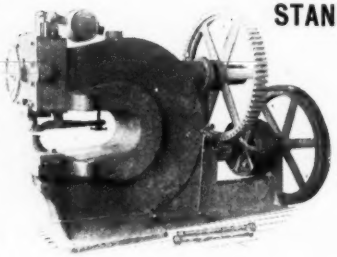

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Depths of throat, 10 inches to 60 inches.

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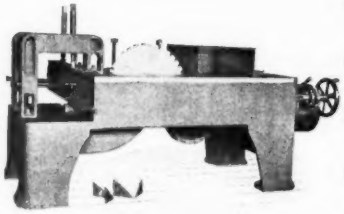

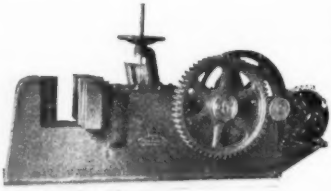

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FOR BENDING AND STRAIGHTENING ANGLES, CHANNELS, RAILS, BEAMS, Etc.

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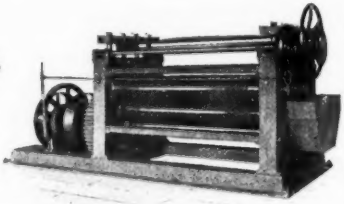

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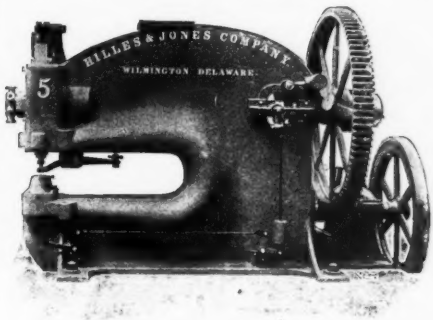

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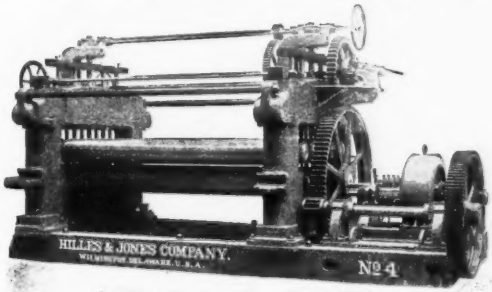

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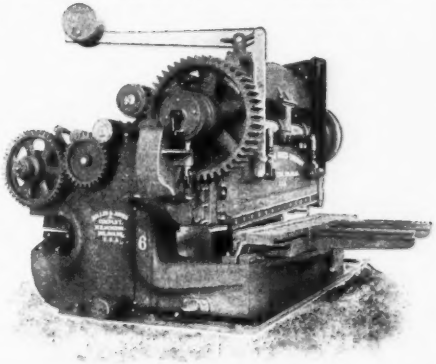

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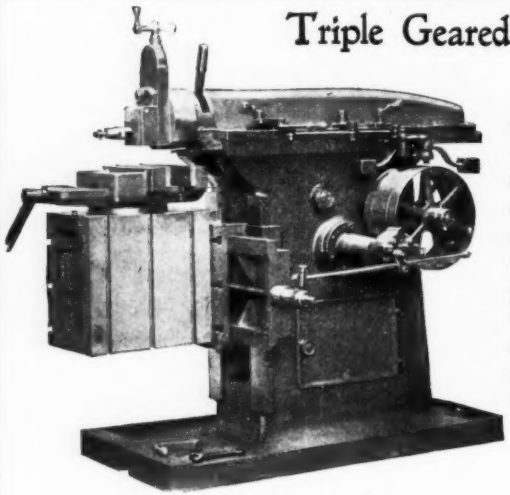

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These machines furnished with regular countershaft, or with special variable speed countershaft (an extra), affording any cutting speed from 9 to 45 feet per minute, with a constant return of the ram at a rate of 60 feet per minute. This revolutionizes the Rack Shaper.

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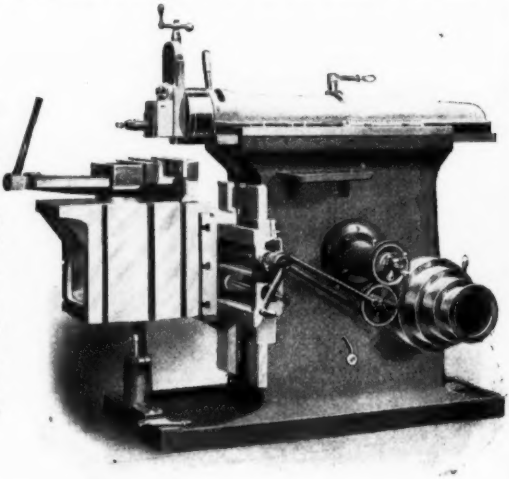

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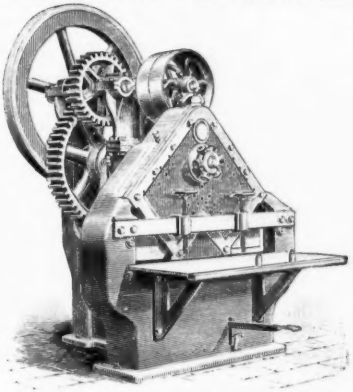

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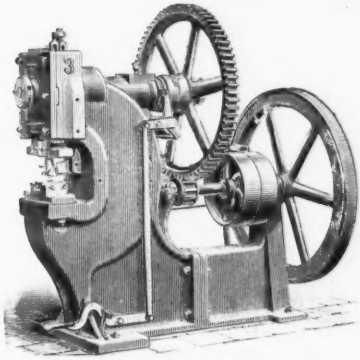

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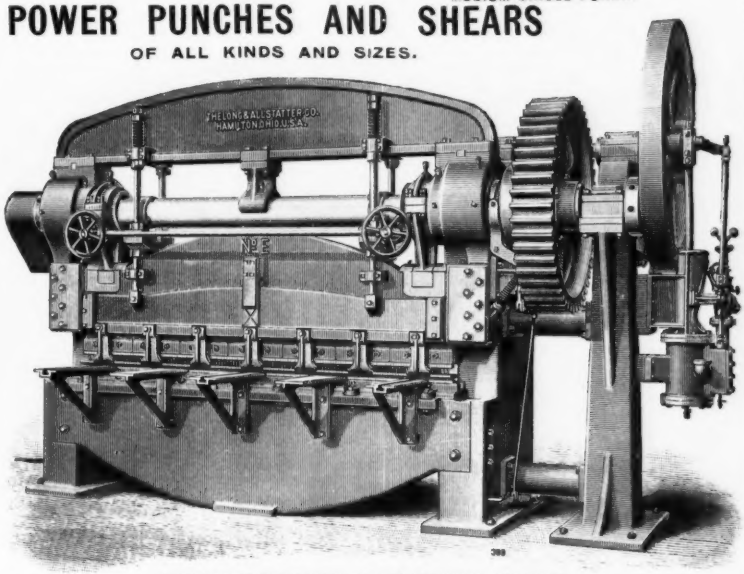

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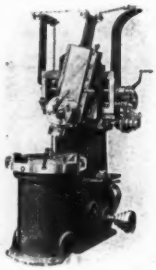

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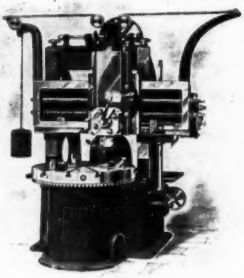

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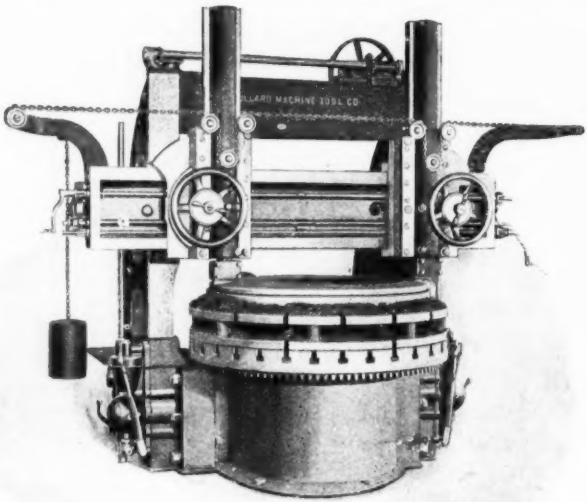

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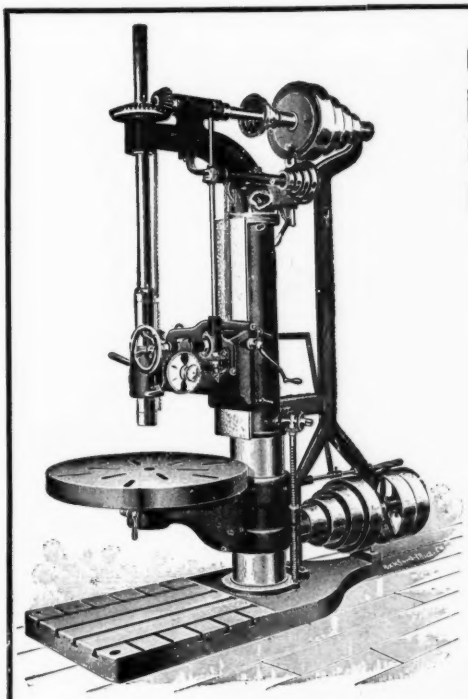

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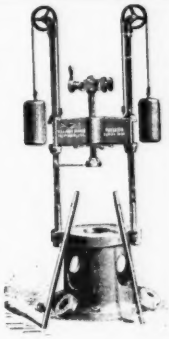

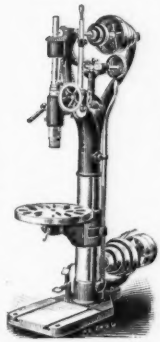

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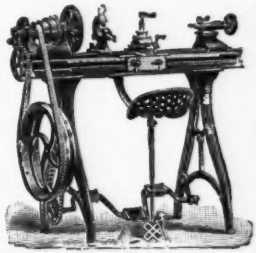

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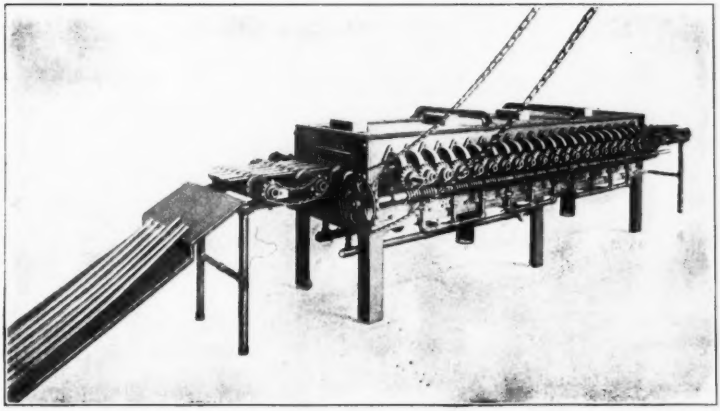

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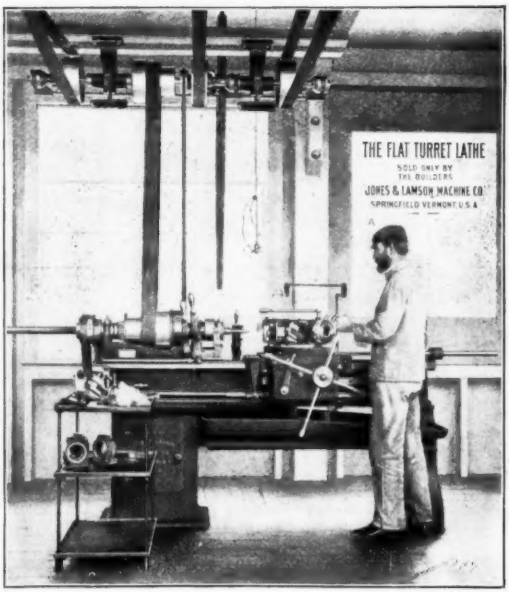

SHOWN in the accompanying cut is used for making all shapes of shafts, studs, and screws under 2 inches in diameter and less than 24 inches in length. It is provided with an outfit of tools making it possible to turn nearly every conceivable shape and size within these dimensions.

It handles full lengths of rough bar stock, and produces the work from four to ten times as fast as can be turned out by the engine lathe.

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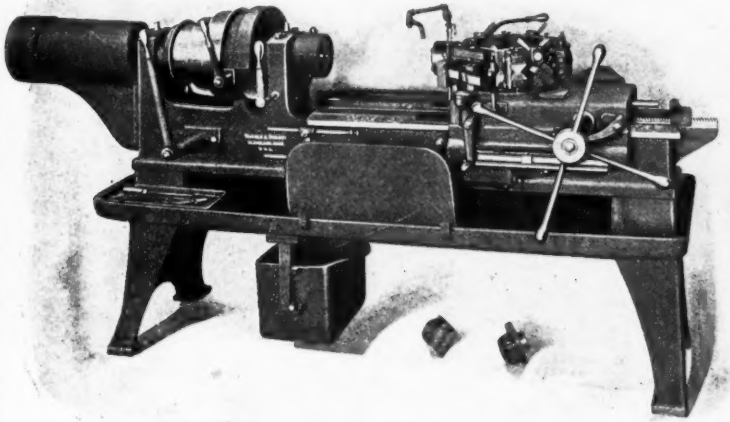

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Range of work 2 inches in diameter, 24 inches long; head cast solid with bed; Automatic Chuck and Roller Feed; large Hexagon Turret with Independent Stop for each Tool and Supplementary Stops for squaring shoulders on work; Geared Feeds to Turret Slide changeable instantly by lever in front of head without stopping machine. Complete set of tools furnished with Machine.

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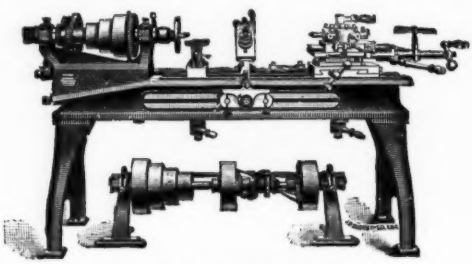
LATHES



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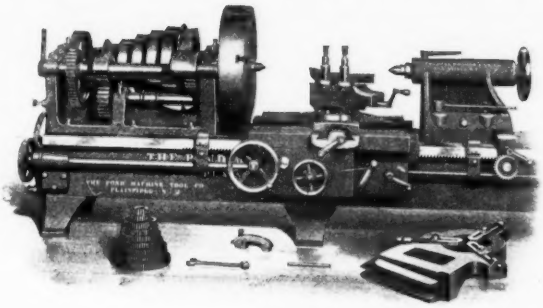

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ALL SIZES

IN

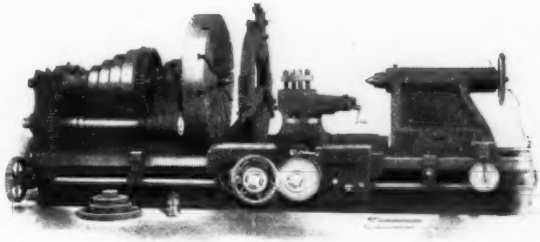
..STOCK..

28 inch

to

84 inch

Swing.



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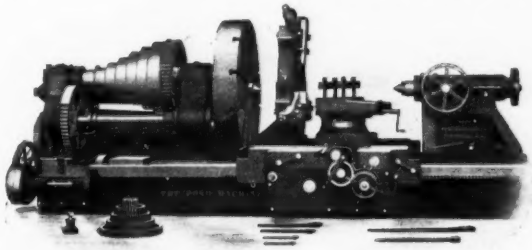

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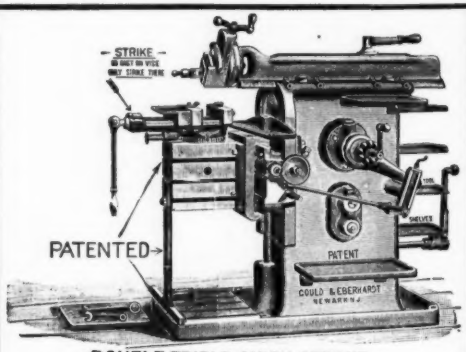

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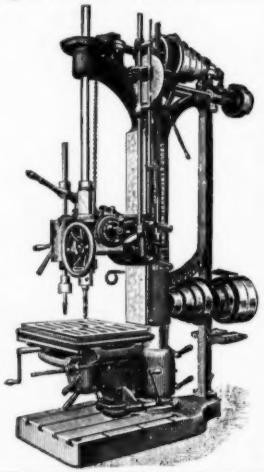

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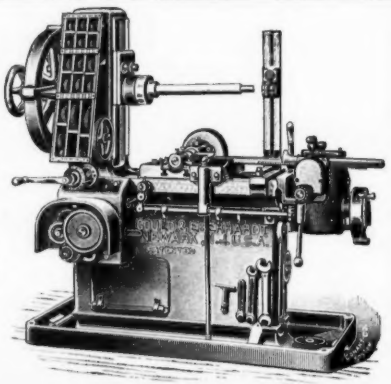

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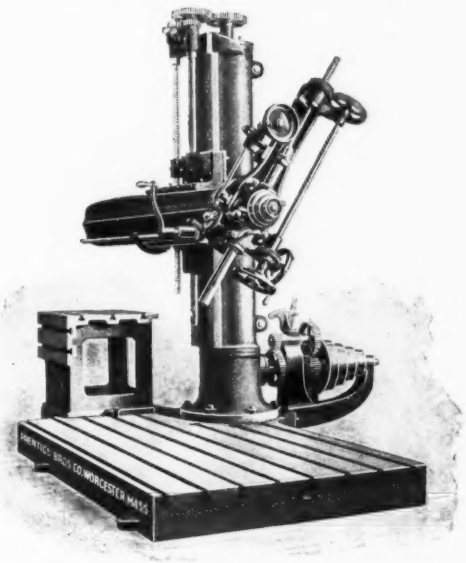

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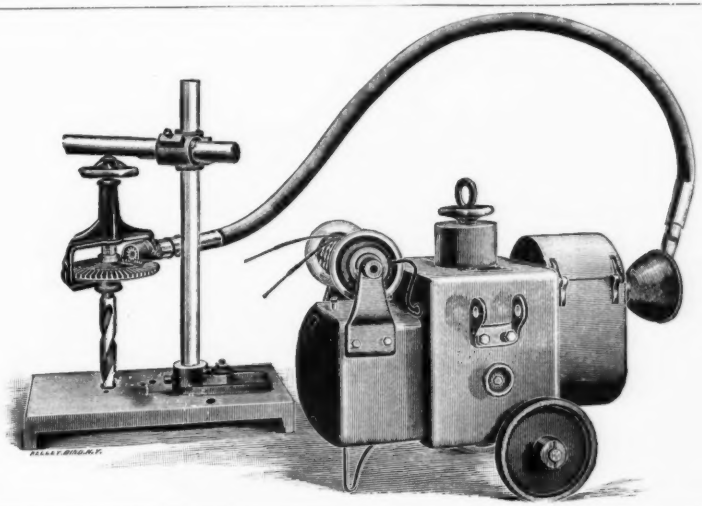

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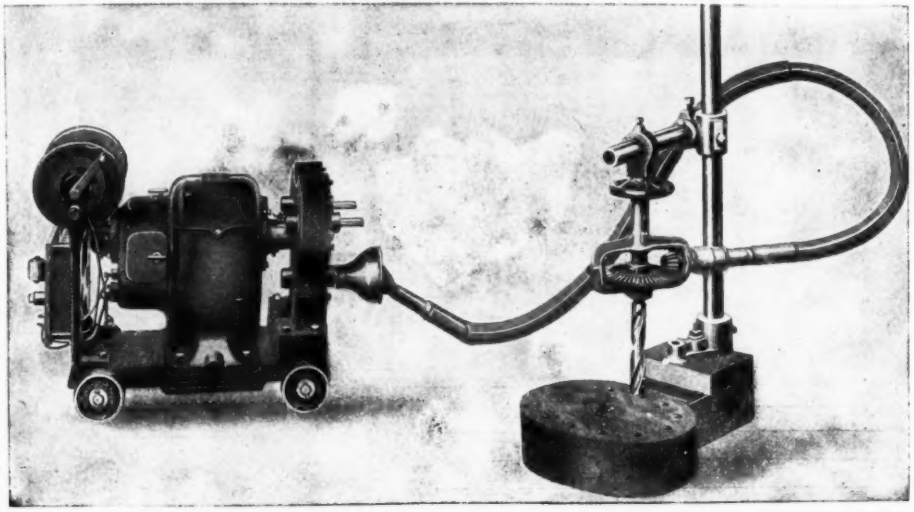

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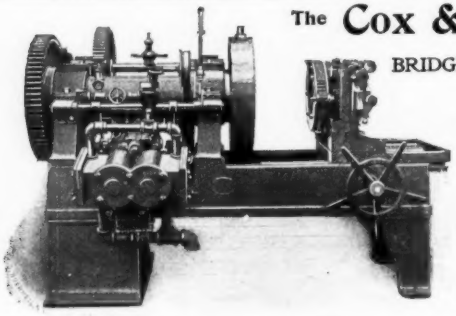

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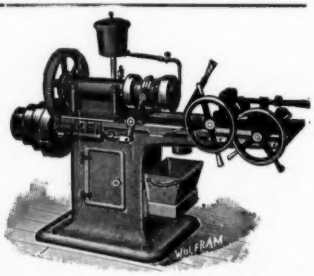

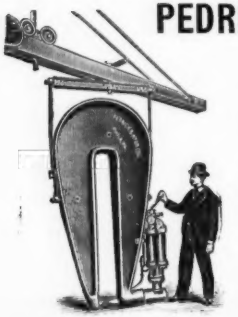

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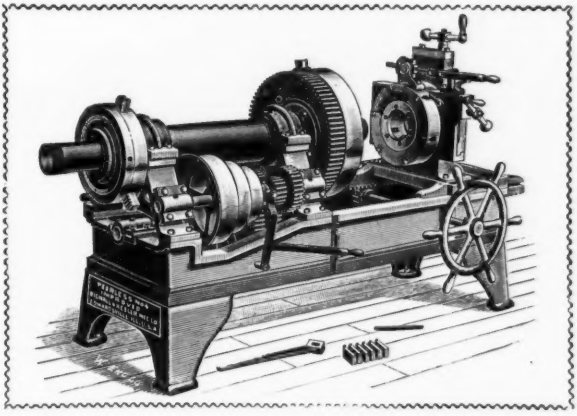

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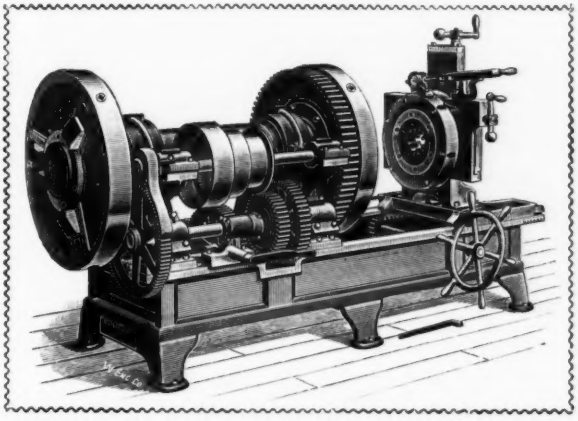

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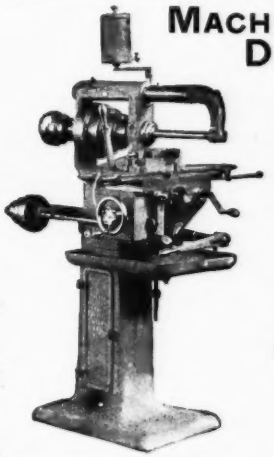

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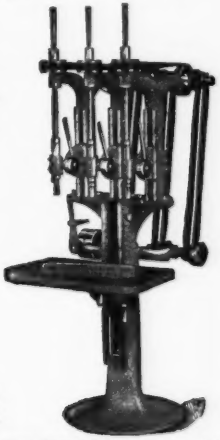

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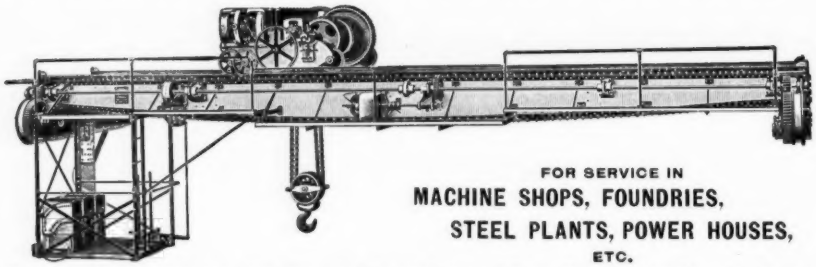

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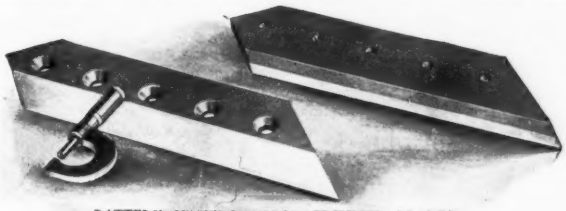

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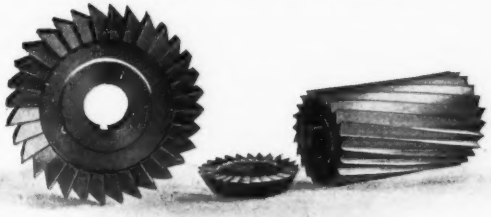

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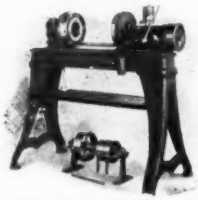

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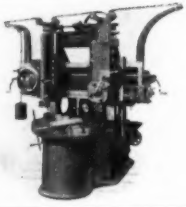

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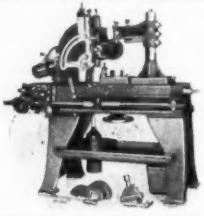

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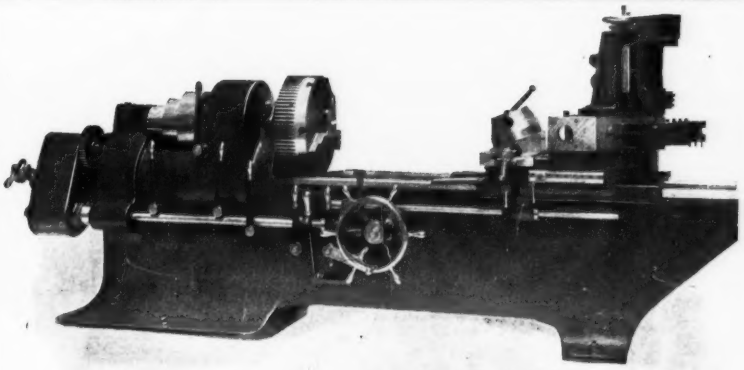

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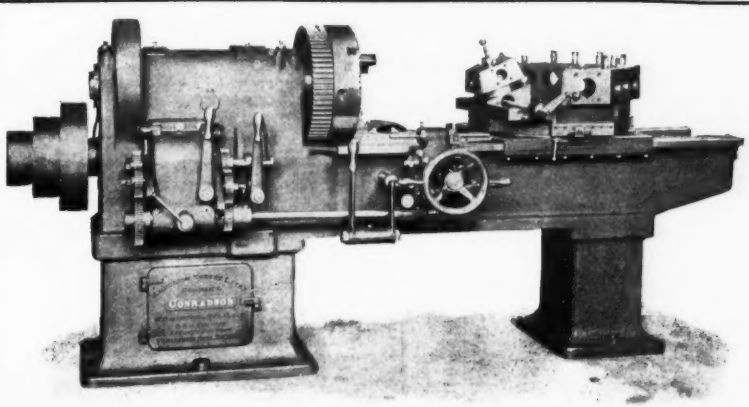

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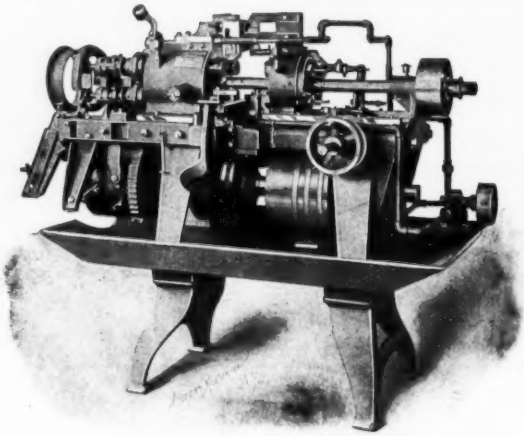

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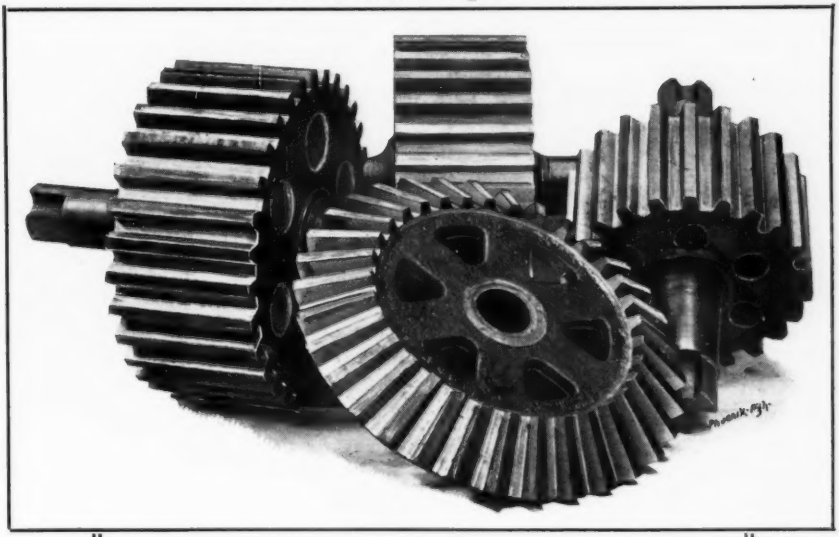

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" " "	"	544068,	Aug. 6, 1895
" " "	"	558497,	Apr. 21, 1896.
" " "	"	560171,	May 12, 1896.
Baush Patent	No.	466553,	Jan. 5, 1892.
" " "	"	515988,	Mch. 6, 1894
" " "	"	563545,	July 7, 1896

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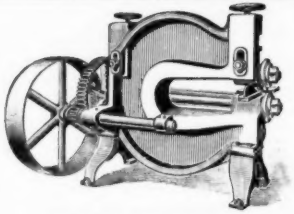

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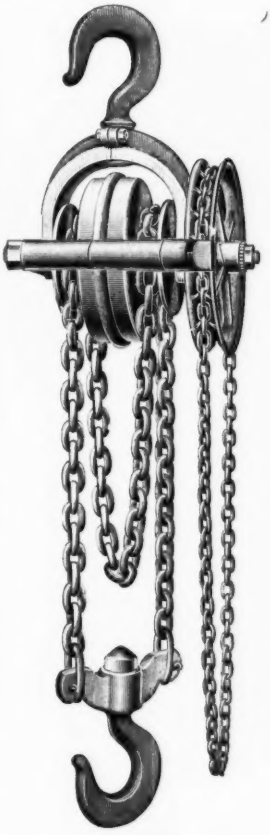

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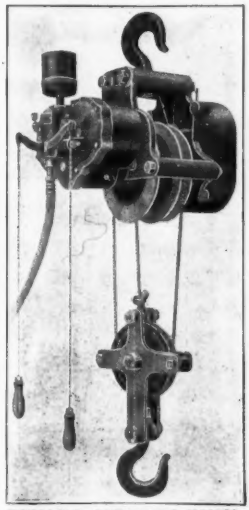

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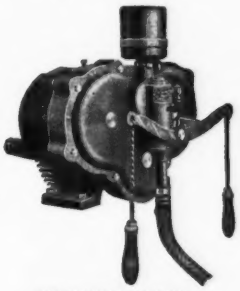

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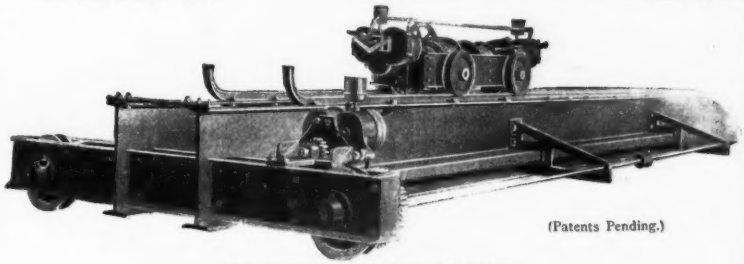

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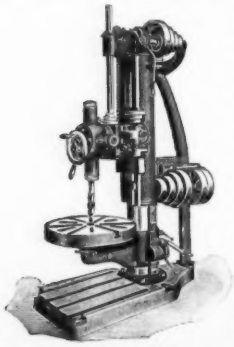

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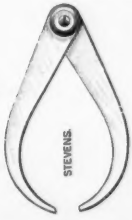

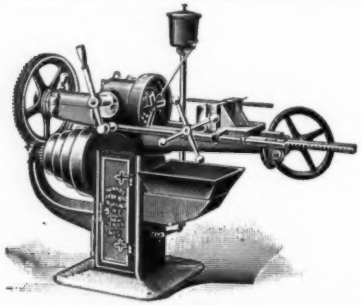

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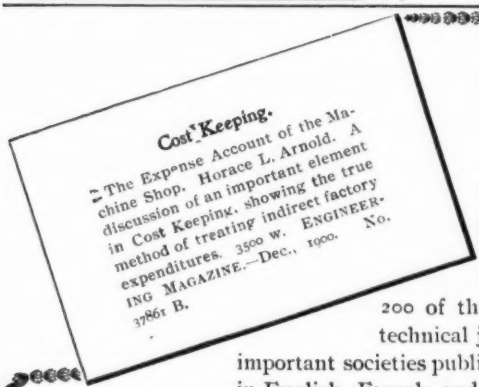

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The Expense Account of the Machine Shop. Horace L. Arnold. A discussion of an important element in Cost Keeping, showing the true method of treating indirect factory expenditures. 3500 w. ENGINEERING MAGAZINE.—Dec., 1900. No. 37861 B.

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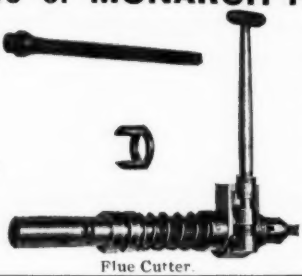

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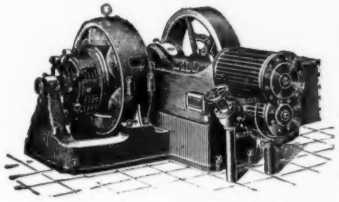

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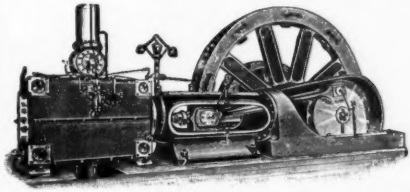

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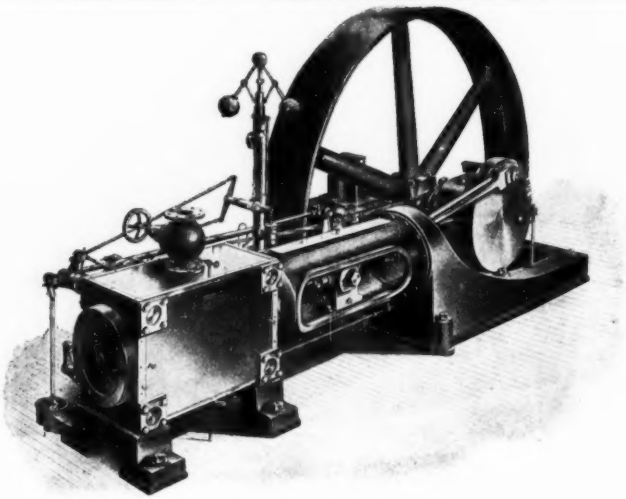

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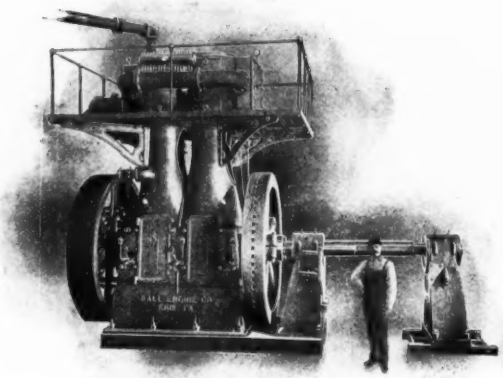

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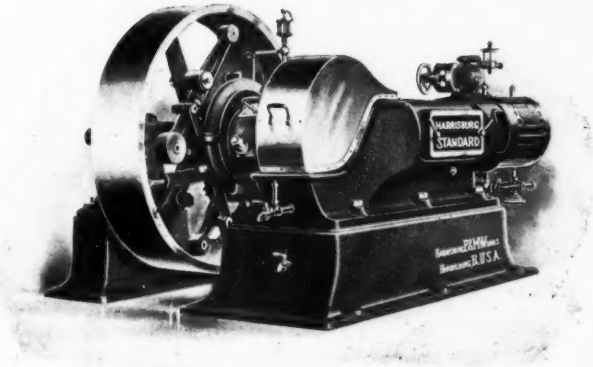

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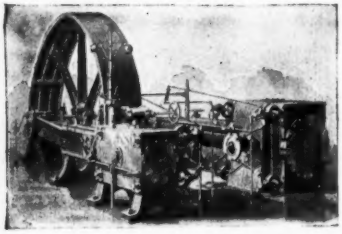

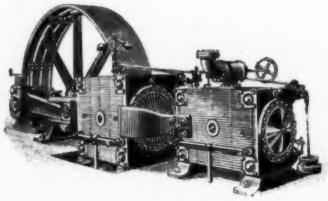

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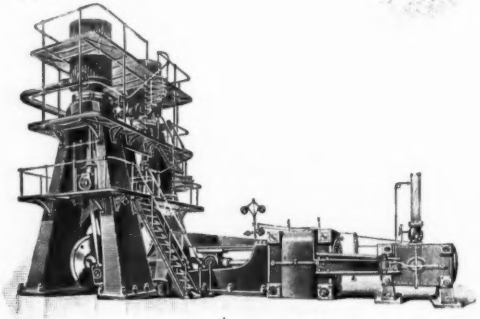

What We Build

- ICE PLANTS—Can or Plate System.
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- CORLISS ENGINES—Condensing or Non-Condensing.
- STEAM BOILER PLANTS and TANK WORK.
- ANY SIZE Required by the TRADE.
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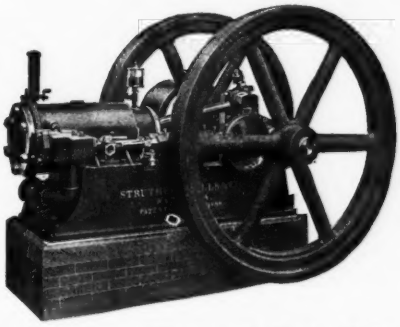
The Warren Gas Engine



This engine is built in Horizontal Single Cylinder type up to and including 90 Horse Power, and in Horizontal Double Cylinder type, from 40 to 180 Horse Power, inclusive. Vertical Multi-Cylinder Engines from 200 Horse Power up.

These are guaranteed for Electric Lighting and all power purposes.

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High Grade Steam Boilers,

Self-Supporting Steel Stacks,

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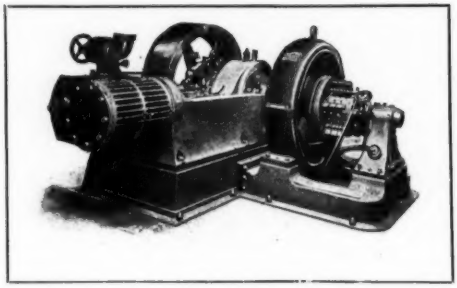
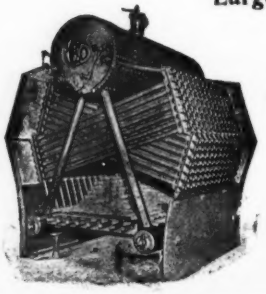
DIRECT CONNECTED. BELTED.



AND

Worthington WATER TUBE Sectional Steam Boiler.



Large Power in Small Space.

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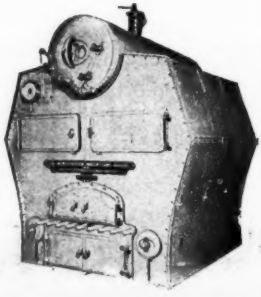

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High Grade Water Tube Boilers.

THE

Stirling Boiler for Stationary Work.

OVER 1,000,000 H.P. IN USE.

All wrought metal and no flat surfaces under pressure.
Four man-holes give access to all parts of the interior.

SIMPLE. DURABLE. EFFICIENT.

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Used by the Navies of—

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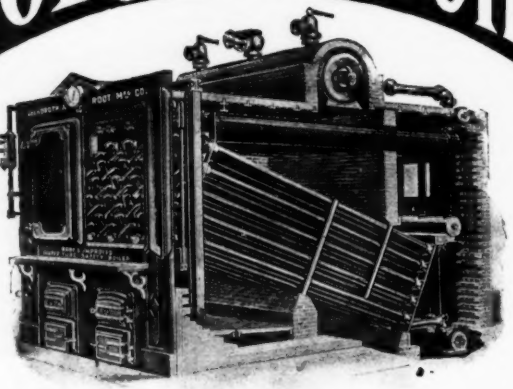
IMPROVED ROOT WATER TUBE BOILER



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Safety, Durability, Efficiency. **Flexibility and Free Suspension.**

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7.—The ***only*** water tube boiler that receives, in its mud drum, all the mud contained in the feed water.
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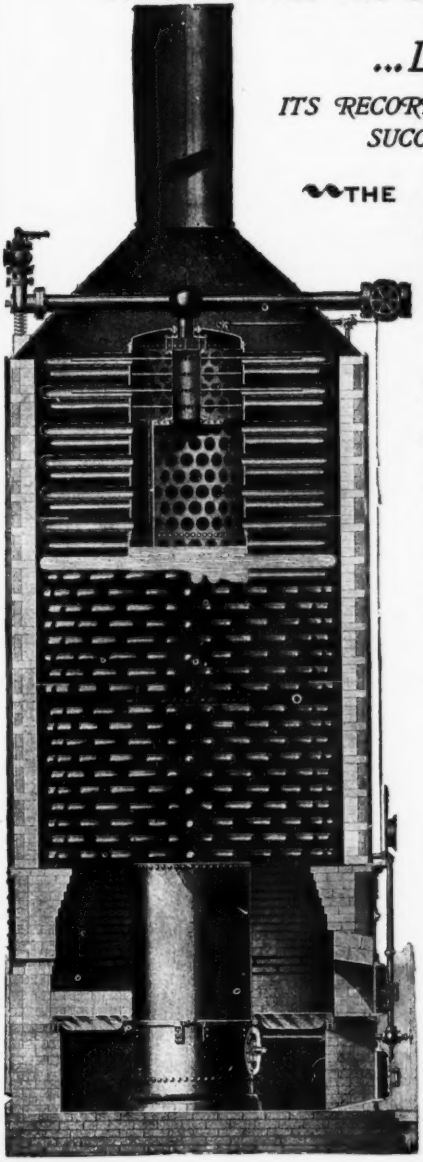
THE HAZELTON BOILER.

A HIGH-PRESSURE WATER-TUBE BOILER COMBINING ALL THE BEST FEATURES.



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ITS RECORD OF TWENTY YEARS' SUCCESSFUL SERVICE.

THE **HAZELTON BOILER**

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NEW...

STEEL-CLAD SQUARE-FURNACE AND CIRCULAR STEEL-JACKET

is not only the best boiler WE have ever made, but is the best boiler ANYBODY has ever made.

The truth of this statement will be fully demonstrated by an inspection of the boilers of our present manufacture.

THE MOST PERFECT

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UNEQUALED FOR

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CORRESPONDENCE SOLICITED.

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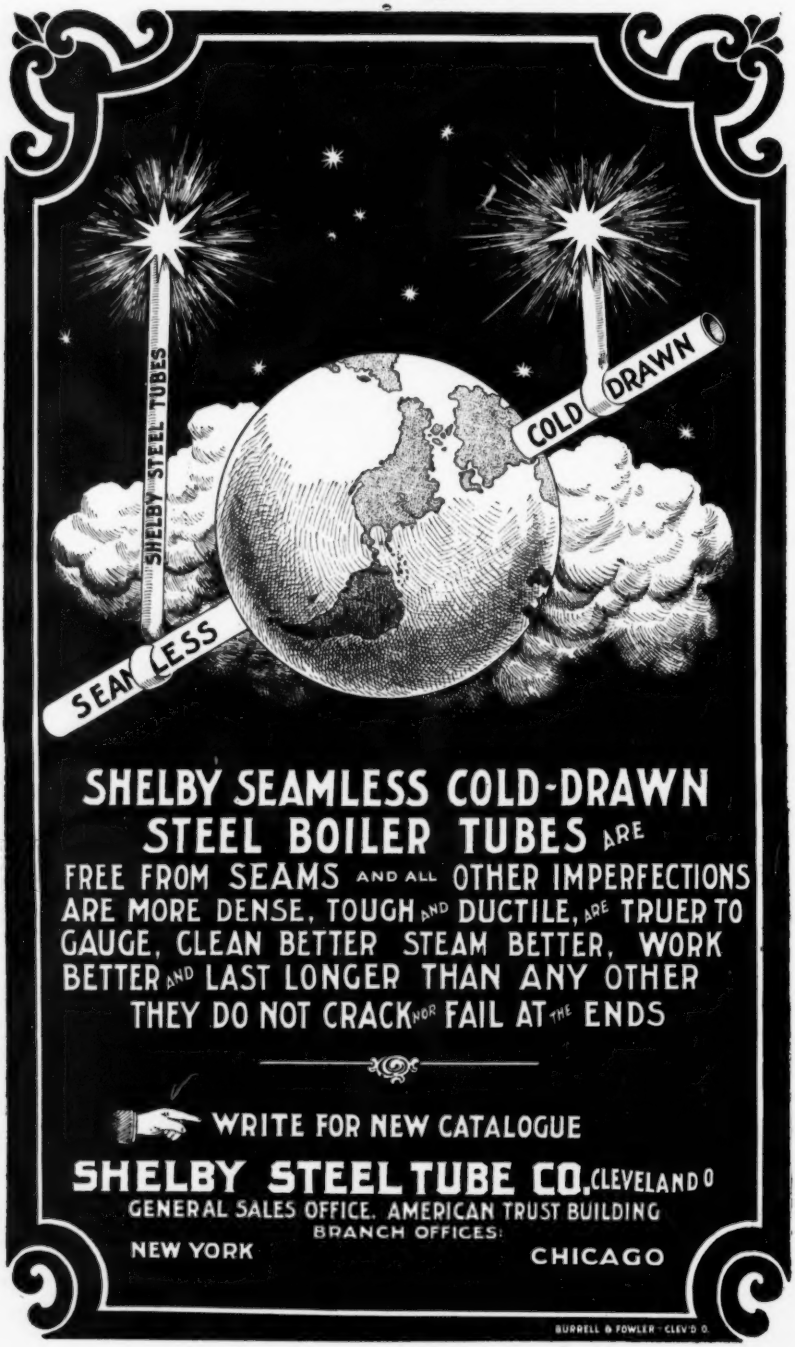

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STEEL BOILER TUBES ARE
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ARE MORE DENSE, TOUGH AND DUCTILE, ARE TRUER TO
GAUGE, CLEAN BETTER STEAM BETTER, WORK
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Let us assist you to keep the New Year Resolutions to stop smoking and save money.

Smokelessness and Economy guaranteed.

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SAVE YOUR MONEY

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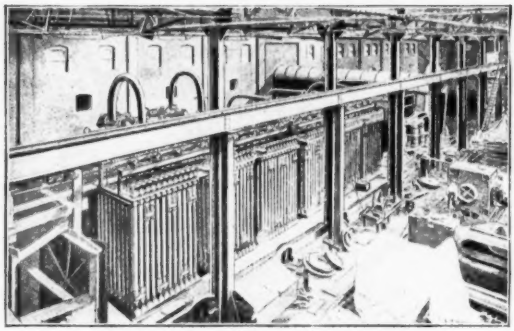

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Is an important factor for Electric Light, Power Supply and Traction Plants, Distilleries, Refineries, Mines, Mills, Pumping Stations, and Hydraulic Power Plants.

Because it utilizes an otherwise wasted product for heating your feed water.

Taking the water from the hot well at 110° an Economizer will heat the feed-water up considerably above boiling point, and you can therefore make all your auxiliaries condensing or electric driven and gain a large saving in consumption of fuel, and you always have a large supply of hot water sufficient to meet any sudden demands for power.

Saving 10 to 20 per cent. in Fuel Expenditure alone.

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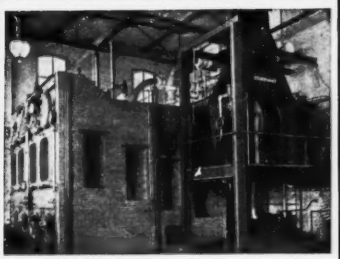
SOLE MANUFACTURERS IN THE U. S. A.

IT DOES AWAY WITH A CHIMNEY



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COSTS FAR LESS

Is independent of weather. The fan is positive in action. Responds instantly to sudden demands for more steam. Burns cheap fuel. Costs practically nothing for operation when exhaust steam is utilized

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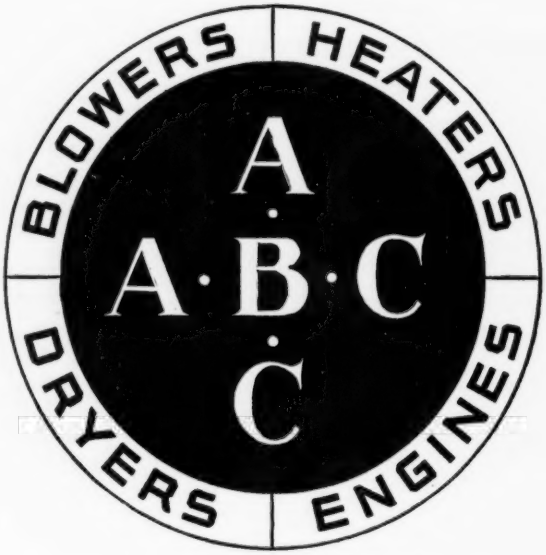

WE MANUFACTURE A LINE OF APPARATUS, WHICH FOR SCIENTIFIC DESIGN, WORKMANLIKE FINISH AND HIGH EFFICIENCY, HAS NO EQUAL. CATALOGUES SENT ON APPLICATION TO OUR MAIN OR BRANCH OFFICES. . . . . .

FOR HEATING, VENTILATING, DRYING AND MECHANICAL DRAFT PLANTS IT IS QUITE AS IMPORTANT THAT THE ENGINEERING BE PROPERLY DONE AS THAT THE APPARATUS BE FIRST-CLASS. THE SERVICES OF OUR CORPS OF EXPERTS IS AT THE COMMAND OF OUR PATRONS. . . . . .

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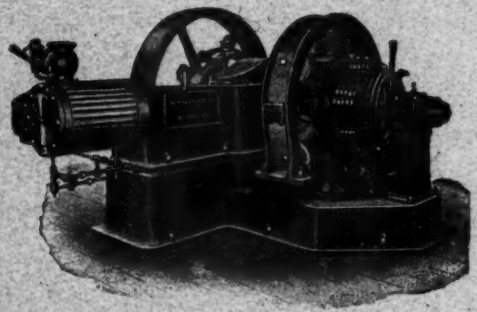
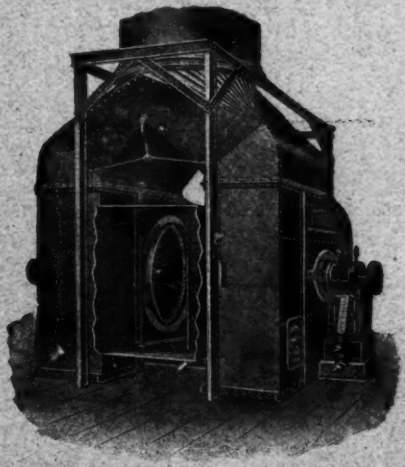


Buffalo Horizontal Center Crank Engine.
RUNNING IN OIL.



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HIGH SPEED ENGINES FANS BLOWERS DOWN DRAFT FORGES

Please mention The Engineering Magazine when you write.

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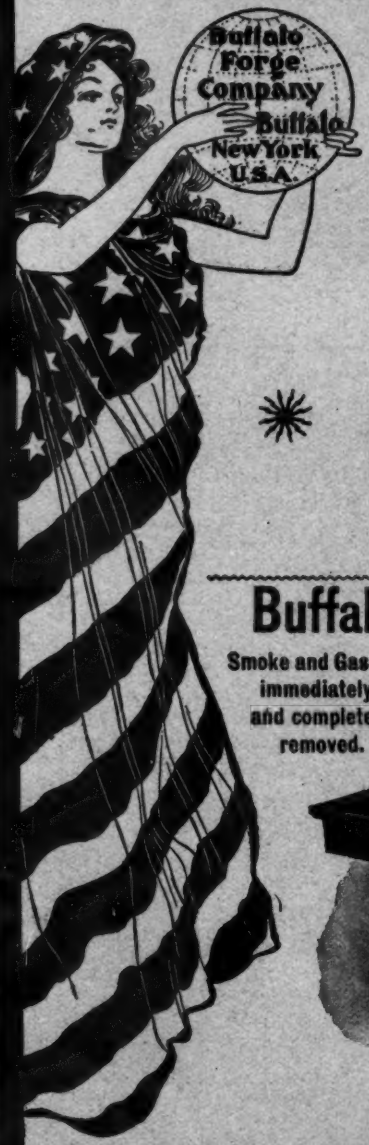

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Buffalo Cupola Blower on Adjustable Bed.

Buffalo DOWN DRAFT Forges.

Smoke and Gases immediately and completely removed.

Patented and exclusively controlled by this Company.

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THOROUGH INSPECTIONS

...AND...

Insurance against Loss or Damage to Property and Loss of Life and Injury to Persons caused by

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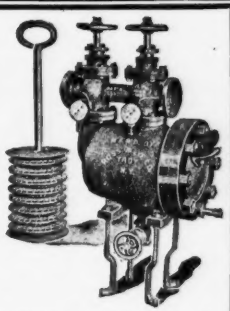
Keep Out Oil.



The function of this filter is to prevent oil getting into your boilers, and is used wherever a condenser is used.

It is extensively used, both on land and sea.

Send for illustrated circular giving details and list of principal users.

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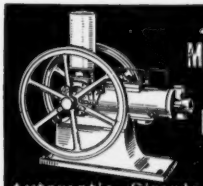

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Automatic, Simple and Reliable
Safest and Cheapest Power Known
From 1 to 40 H. P. Send for Catalogue.

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120,000 SETS IN USE.
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HAVE FOR SALE New Corliss Engines, Simple, Compound and Condensing. Sizes ranging from the smallest up to a 1000 H. P. Now ready for delivery, one 18 x 42 right hand, and one right hand and left hand. 14 x 36. Don't fail to write me before placing order, as prices cannot be duplicated.

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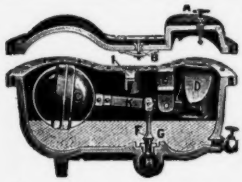

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Discharges continuously and never blows steam.
Made Extra Heavy for High Pressure.

We also Manufacture REDUCING VALVES, EXHAUST PIPE HEADS, SEPARATORS for LIVE and EXHAUST STEAM, BLOW OFF VALVES, RELIEF VALVES, EJECTORS, Etc. ....*Send for Catalogue*

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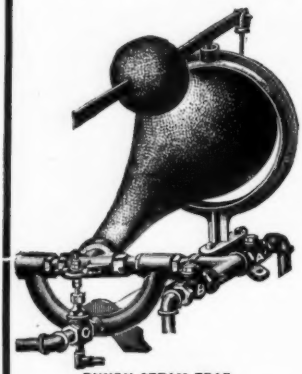

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Made in 32 sizes, capable of handling from 300 to 133,000 lbs. of water per hour.

BUNDY SEPARATOR.
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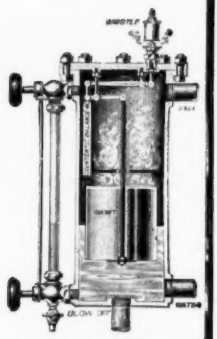
Made in 46 sizes, from 1½ to 30 inches.



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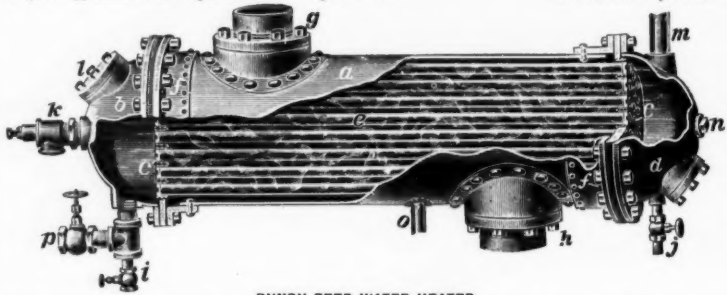
Prevents boiler explosions by warning you when the water is low in your boiler.



BUNDY FEED WATER HEATER.
(Vertical and Horizontal). Made in 70 sizes, from 40 to 7,000 H.P. All sizes up to 700 H.P. kept in stock.

BUNDY EXHAUST HEAD.
Made in 27 sizes, from 1¼ to 48 inches.

IT MAY SAVE YOU

a great many dollars (hundreds in the original purchase and thousands in the after saving effected) by getting our prices before ordering elsewhere these goods.

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A. A. Griffing Iron Company,

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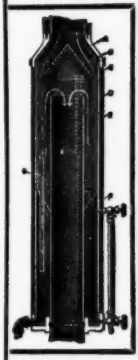
Makers also of Bundy Steam and Water Radiators and Boilers.

ALL THE TIME

SWEET'S SEPARATORS



are efficient when engines are running light, heavily loaded or boilers hard driven and foaming. This may be just the point to consider.

Send for Circulars.
Steam or Oil, all styles.

DIRECT SEPARATOR CO,
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WE MAKE A GOOD EXHAUST HEAD.

THE ONLY ONE.

All Separators have their merits. But the

Stratton Separator

is *the only one* that will take care of a large influx of water, positively separate it from the steam, and keep it separated, and so long as the drain pipe is open no water will be again picked up and carried to the engine. That involves considerably larger proportions and higher first cost. But it is a wise investment—you get your money back over and over again.

"Dry Steam" is the title of our new pamphlet—written by a distinguished engineer—worth money to every intelligent reader. Free to all parts of the world on request.

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HEINTZ STEAM TRAP

Now is the time to overhaul your Steam Heating Apparatus.
Write us about the merits of the Heintz Steam Saver. We can save you both money and trouble. We guarantee to drain all condensation from your pipes without the loss of any steam. Sent anywhere on 30 days' trial

THE WILLIAM S. HAINES CO.
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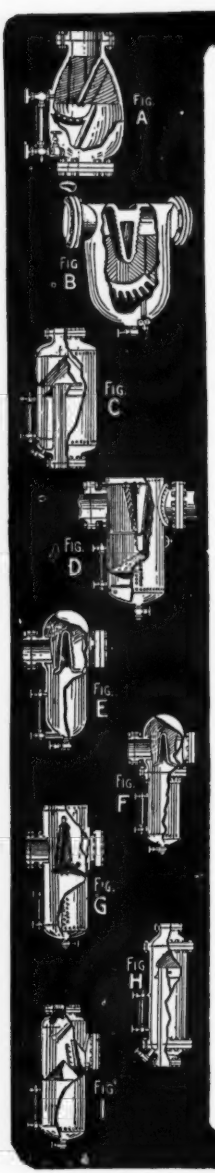

STEAM SEPARATORS.

"XENIA, OHIO, Oct. 6th, 1900.

"THE AUSTIN SEPARATOR CO.,
"Detro t, Mich.

"GENTLEMEN:—

"In reply to yours of Sept. 8th, will say that the 8" Horizontal Separator which we purchased from you is giving entire satisfaction. We find that our engines are doing their work fifty per cent. better than before we placed Separator in our main steam pipe, and with less fuel, oil and attendance. We would not do without it at any price if we could not get another. We can cheerfully recommend your Separator to all persons, and advise those who have none to get one and they will be surprised at the results obtained from using same.

"Wishing you a continuous success, we remain,

"THE XENIA ELECTRIC LIGHT CO.,
"L. L. LUFT, Supt."

Our Separators are made to meet every requirement. The same efficient service, the same universal satisfaction, evidenced by the above testimonial, goes with each and every one.

So confident are we that our Separators will do all we claim, we send to responsible parties on 30 days' trial, and pay all charges if not satisfactory.

You take no chances. Send for our catalog, showing full line.

Austin Separator Company,

26 WOODBRIDGE ST.,
DETROIT, MICH.

L. L. CLINE ADV. DETROIT

Some one once parodied that good old saying, "A rose, by any other name, would smell as sweet," by changing it into "A rose, by any other name, would cost as much."

A COCHRANE SEPARATOR,

HORZ. FORM.

under any other name, would be just as efficient, and would cost as much as it does at present, for, taken in comparison with other Separators, their selling prices are most reasonable.

The service the "COCHRANE" renders is, however, out of all proportion to the selling price. In the matter of taking oil out of exhaust steam, if good separation could be obtained at no other cost, it would still pay the steam user to invest ten times the cost of a Cochrane Separator to be able to use his condensed exhaust for boiler feed and other purposes, thereby saving this pure water and its heat as well.

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The dollars and cents side of it is only one part. First, the service must be obtained at almost any cost. This the COCHRANE SEPARATORS will give you.

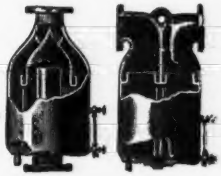
When you consider the price end of it, just remember that low prices are made to move goods that will not sell at the regular prices, because of the strong competition of better goods.

HARRISON SAFETY BOILER WORKS,

Germantown Junction, Philadelphia, Pa.

Hoppes.

FEED-WATER HEATERS, STEAM SEPARATORS.



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LIVE STEAM FEED-WATER

PURIFIERS

Guaranteed to keep Boilers Clean and free from Scale.

THE HOPPES MFG. CO.,

63 LARCH ST., SPRINGFIELD, O.

APPARATUS FOR THE

Softening and Purification of Boiler Water

Before it enters the Feed-Water Heater, so that it will NEITHER SCALE, CORRODE nor FOAM

FOR PARTICULARS ADDRESS **INDUSTRIAL WATER COMPANY** 15 WALL STREET NEW YORK

Ashton Pop Safety Valves, Steam Gages,

AND HIGH GRADE ENGINE AND BOILER FITTINGS.

Unequalled for Efficiency and Durability.
Guaranteed Satisfactory on High Pressures.

SPECIAL FITTINGS FOR STEAM VEHICLES.

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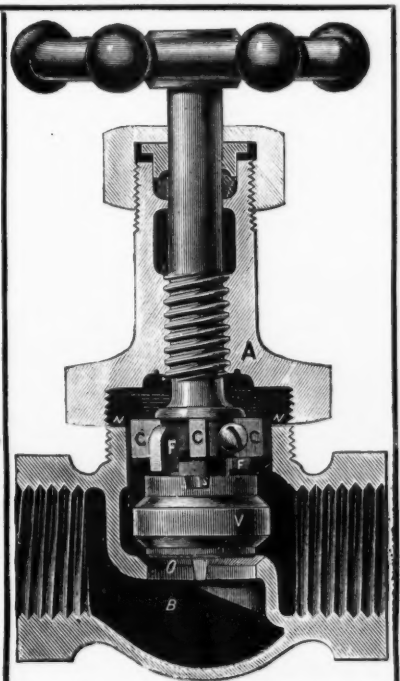

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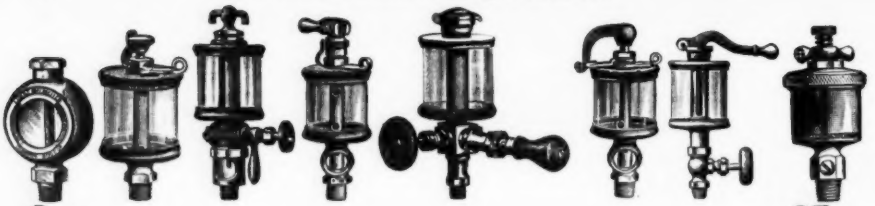

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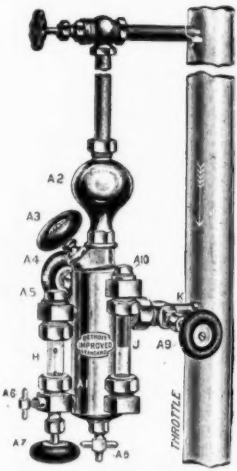

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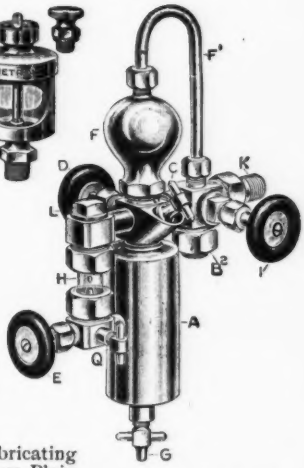

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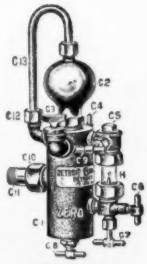

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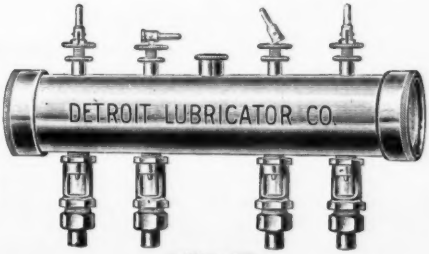

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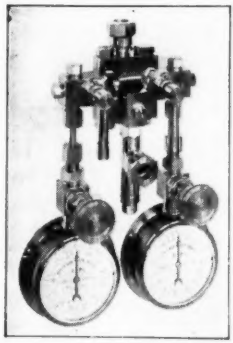

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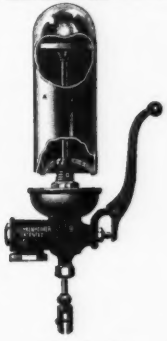

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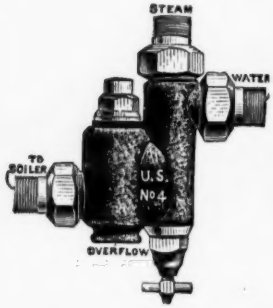

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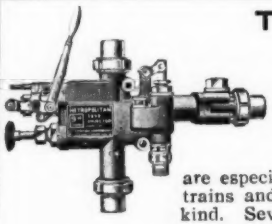

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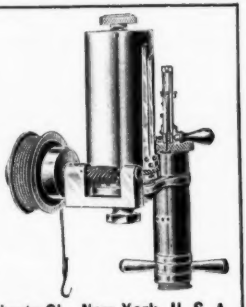

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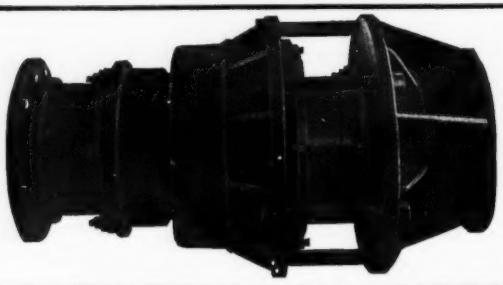

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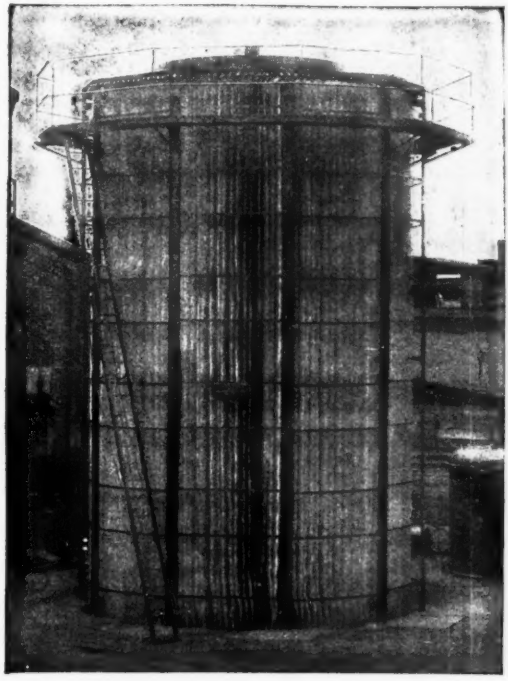

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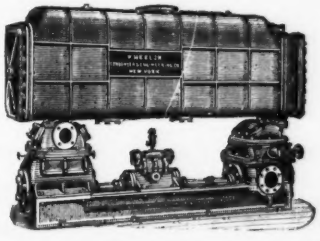

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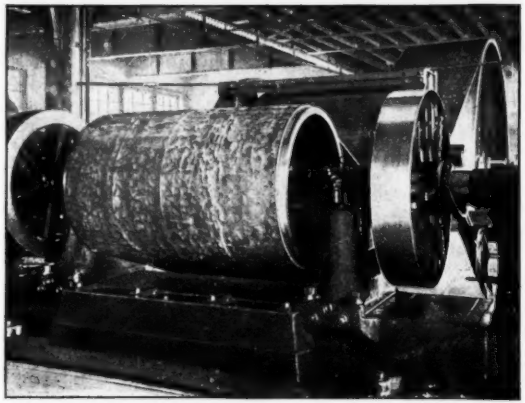

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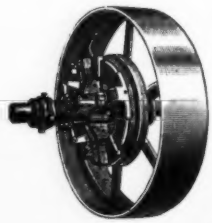

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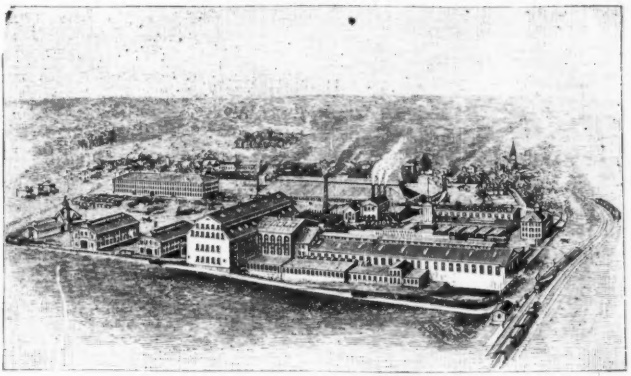

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See Page 6, Section V.

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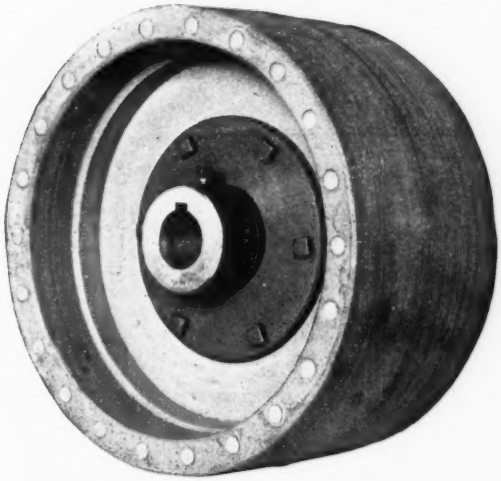

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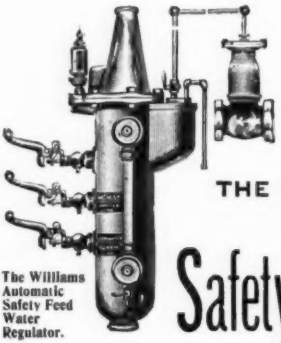

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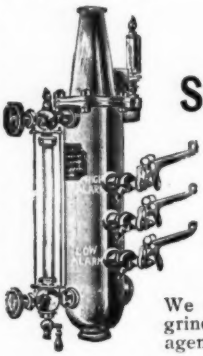

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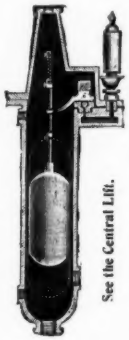

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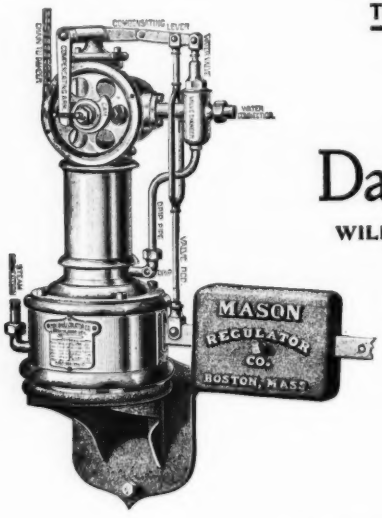

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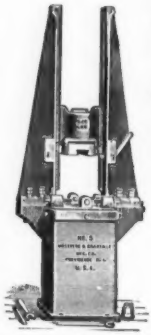

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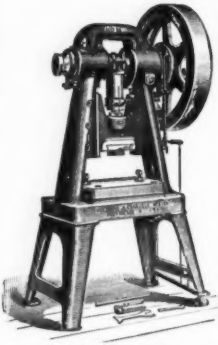

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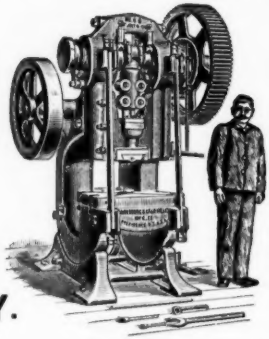

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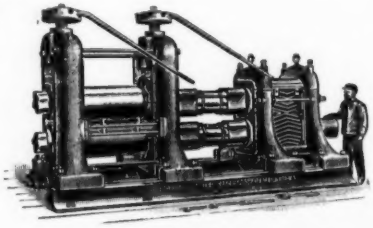

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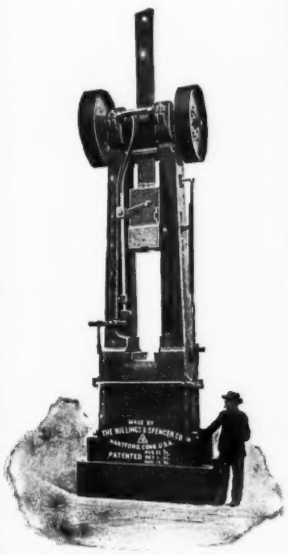

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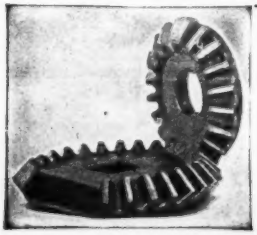

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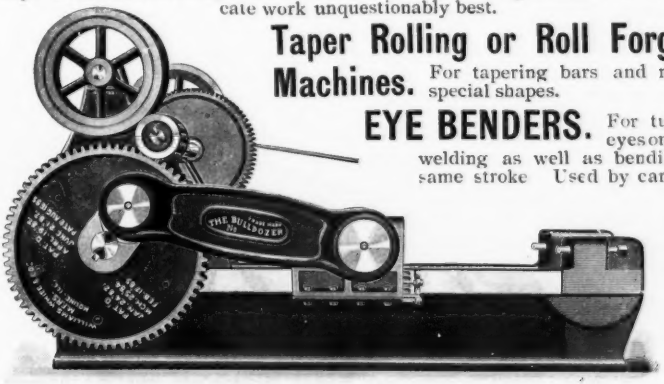

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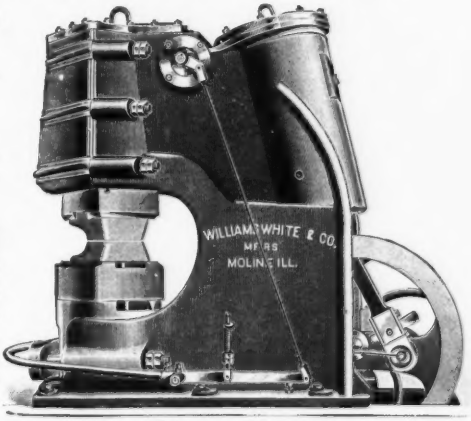

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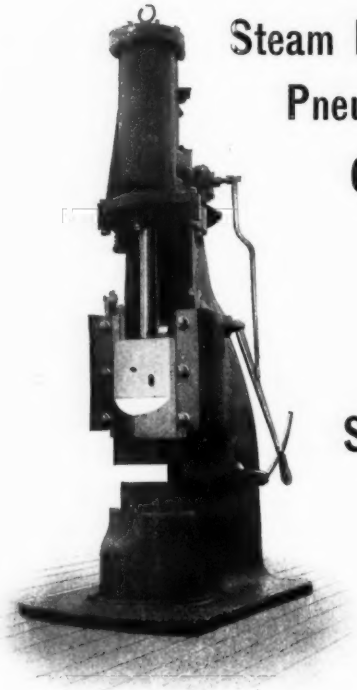

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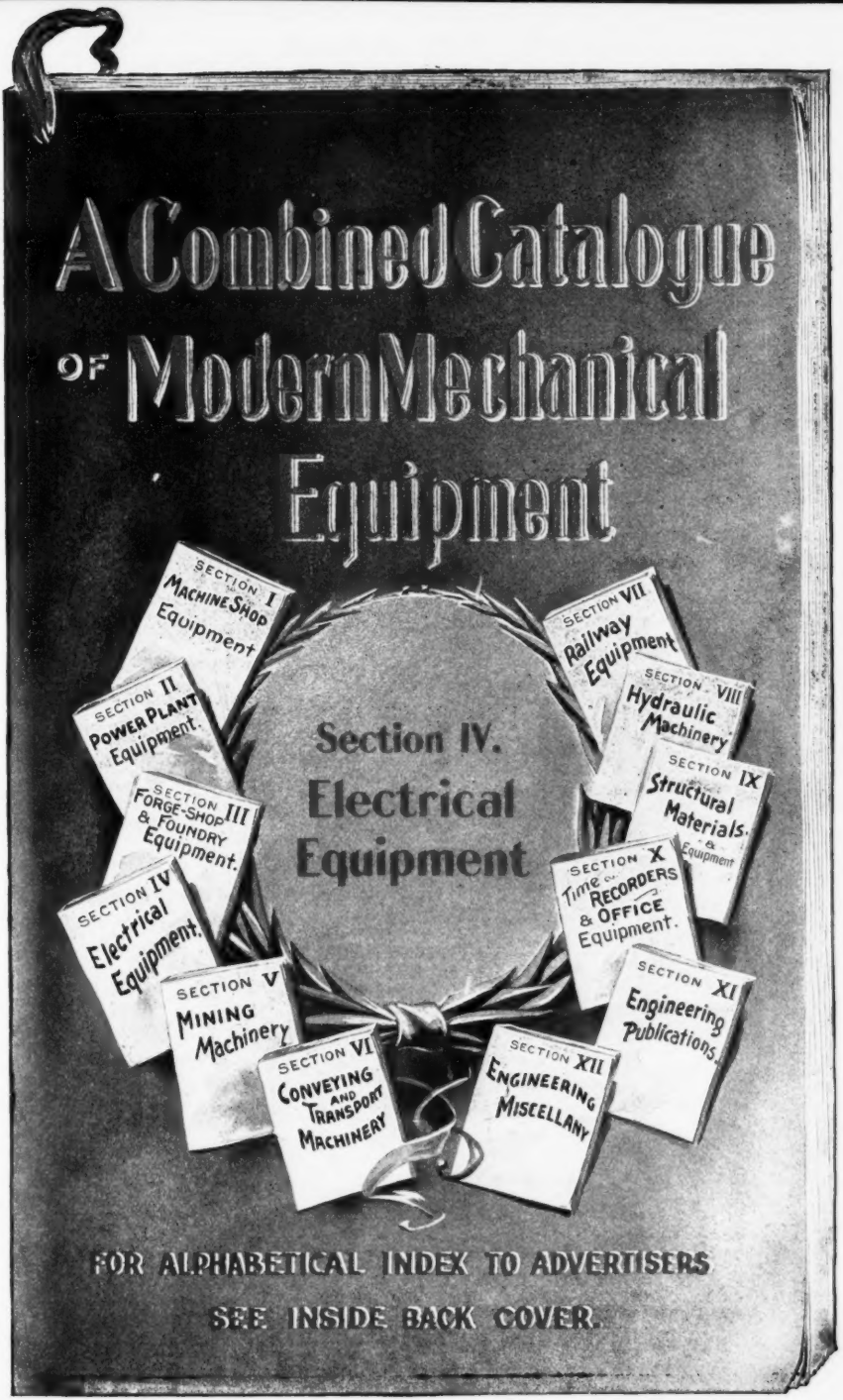

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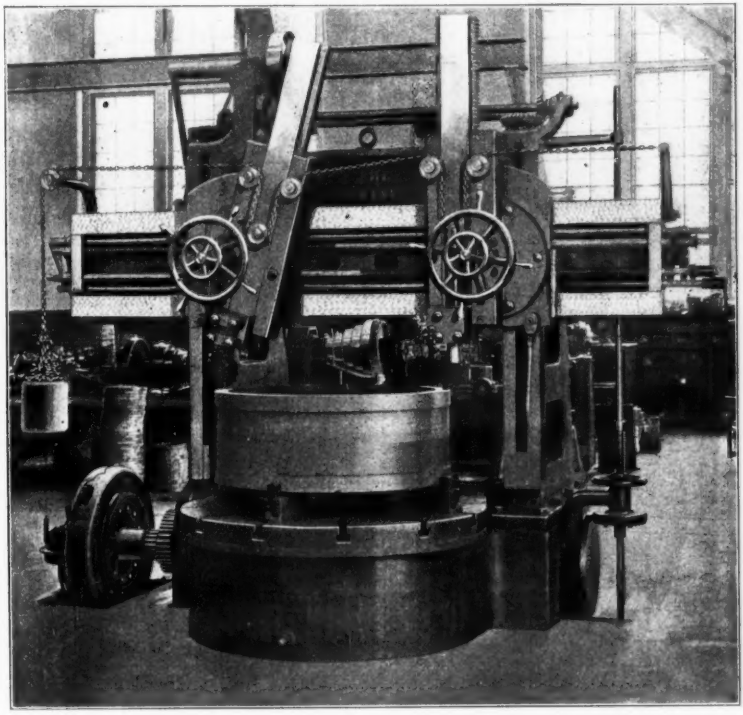

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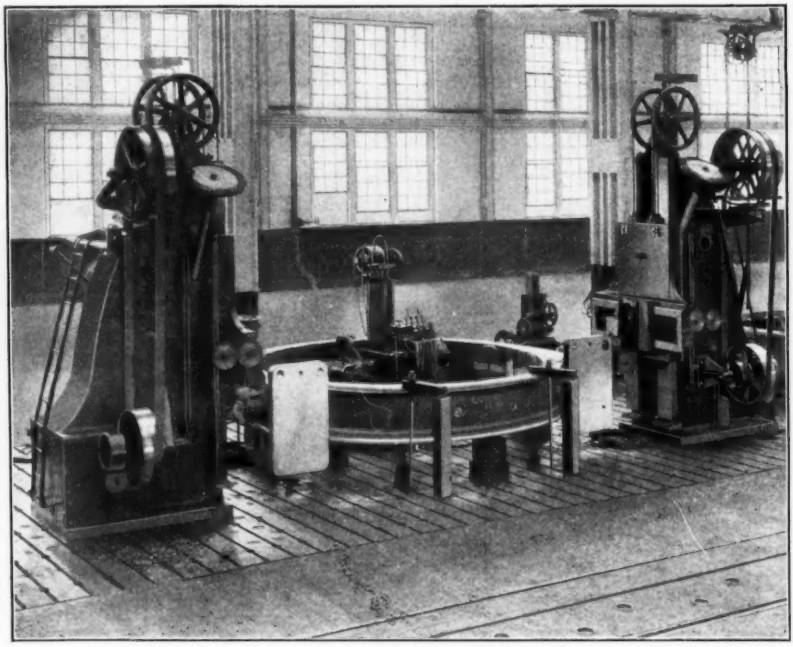

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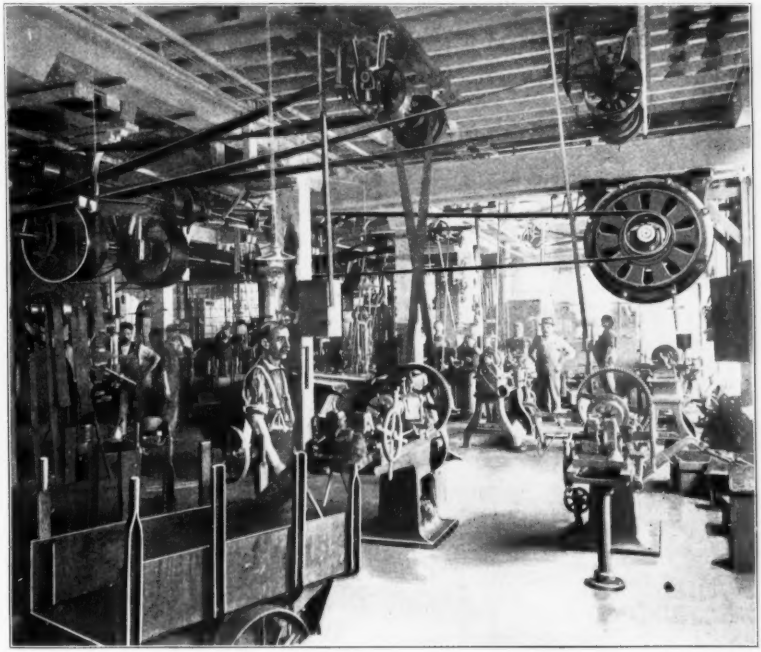

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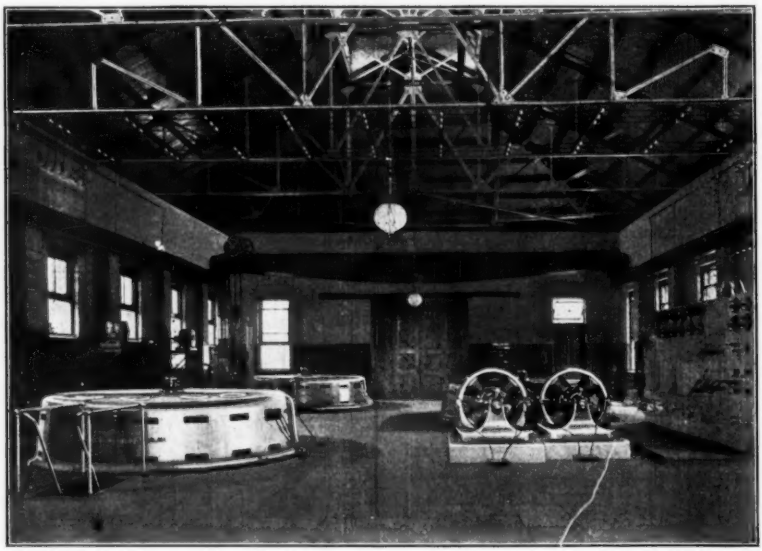

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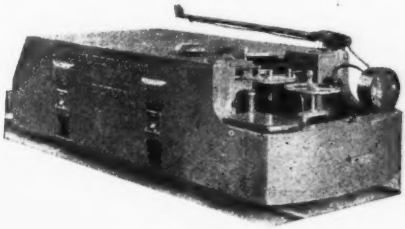

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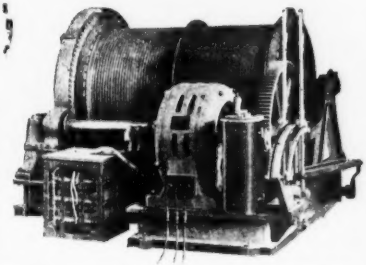

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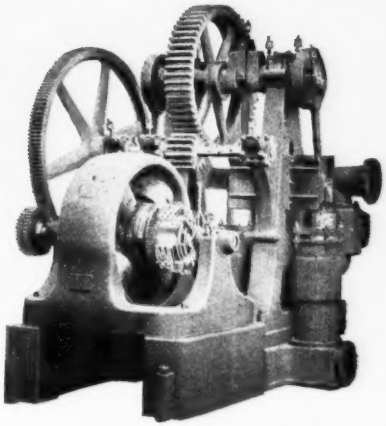

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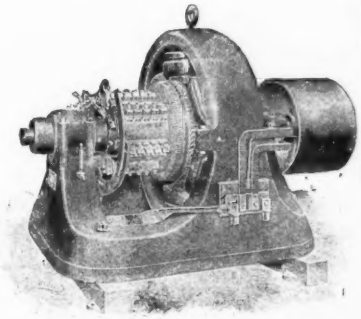

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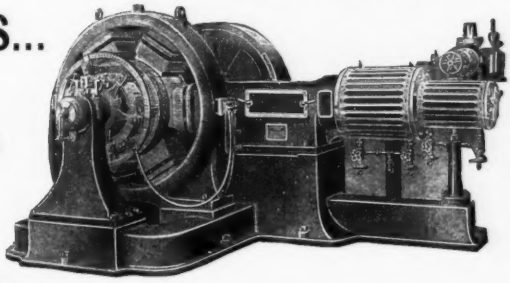

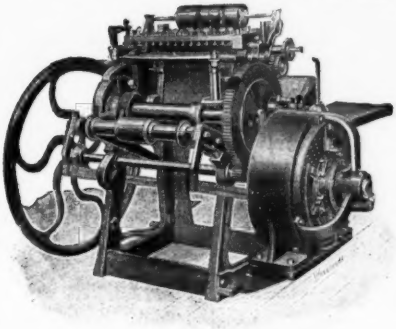

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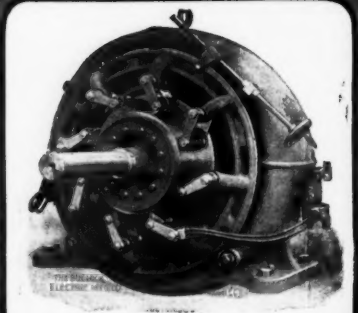
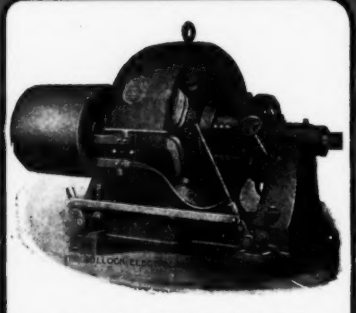


200 K. W. Type "I" Bullock Generator.



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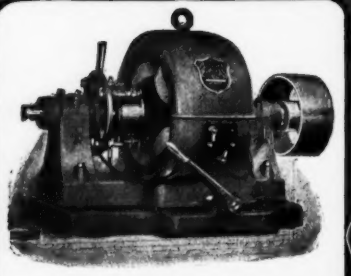
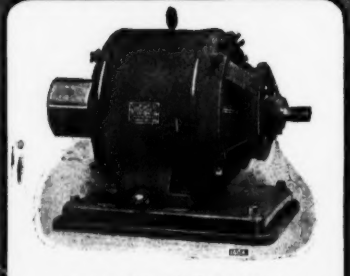


75 H. P. Type "H" Bullock Motor.



25 H. P. Type "N" Bullock Motor.

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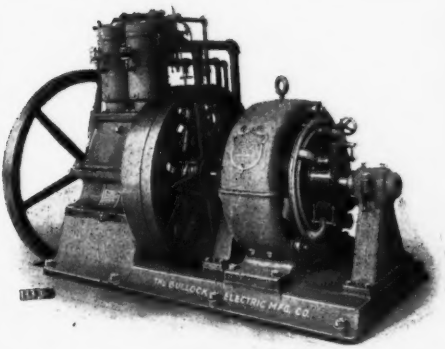

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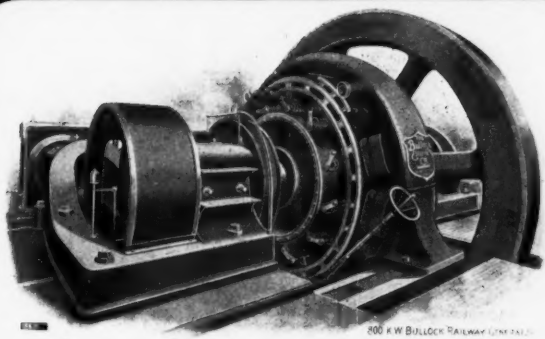

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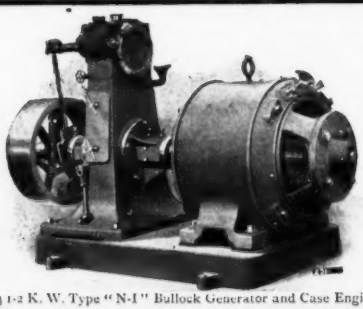

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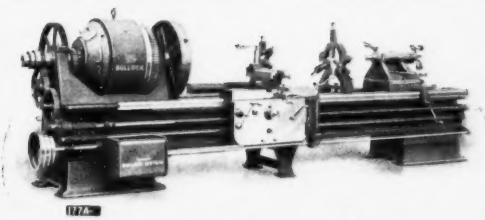

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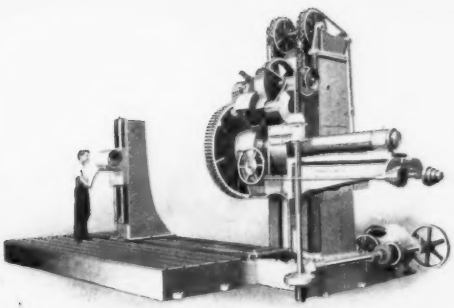

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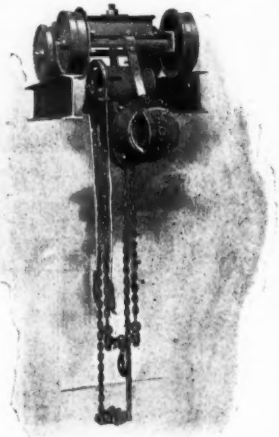

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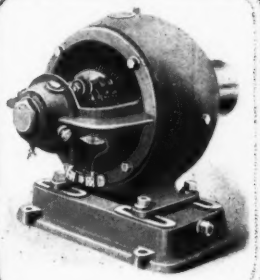

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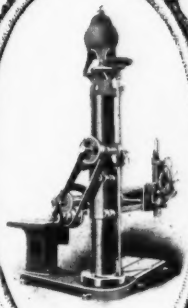

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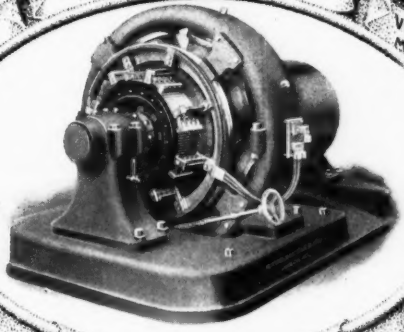

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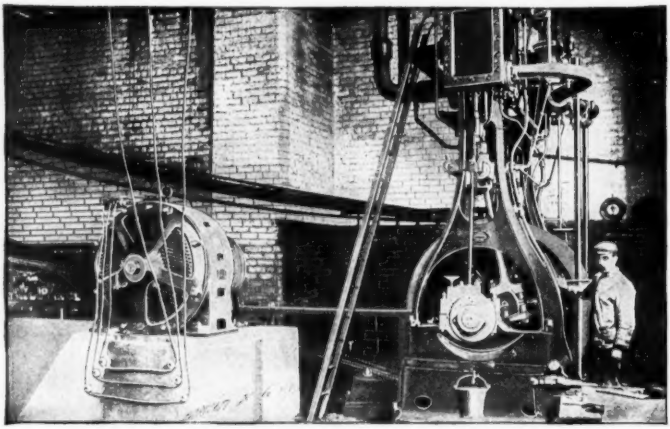

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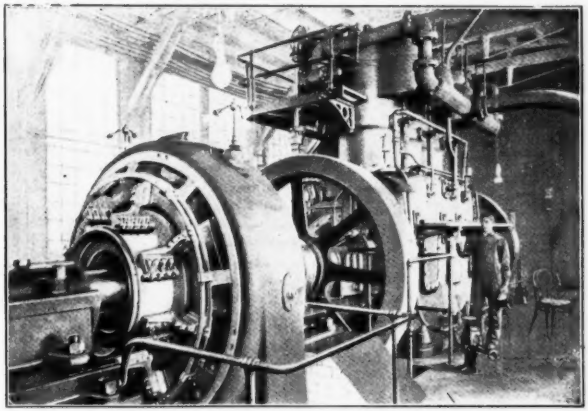

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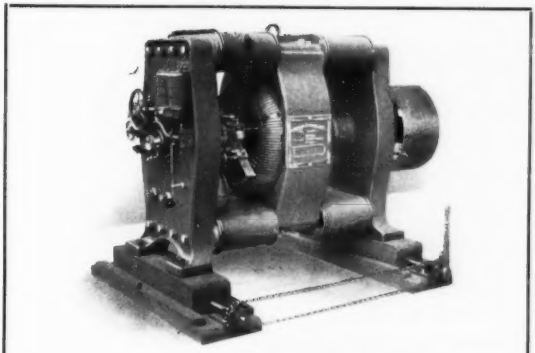

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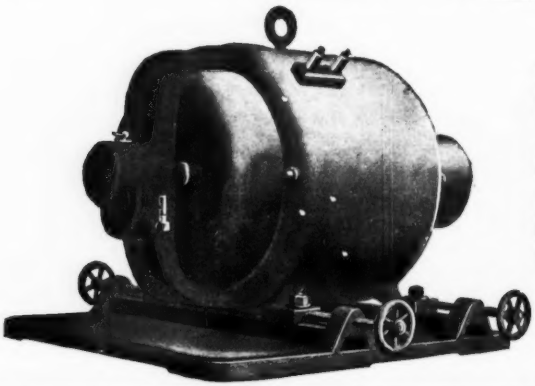

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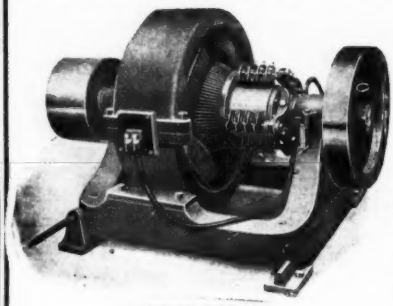

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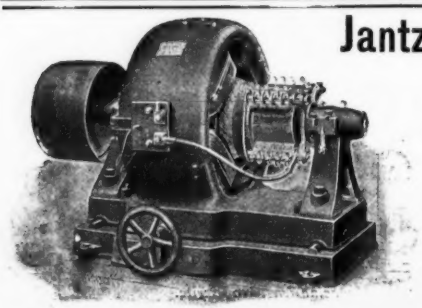

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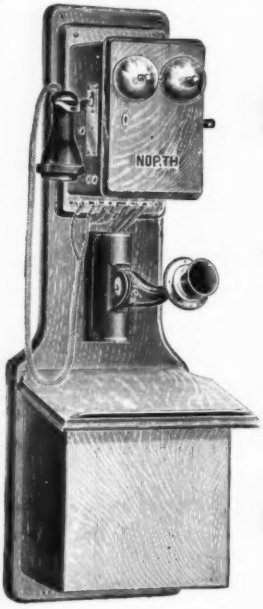

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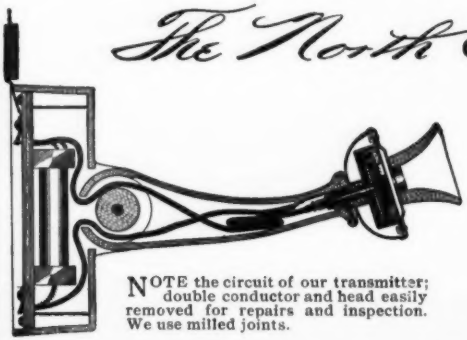

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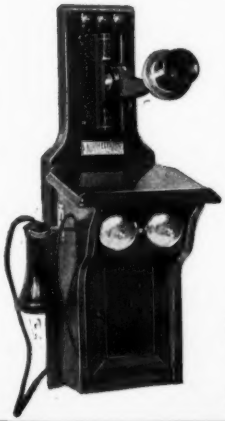

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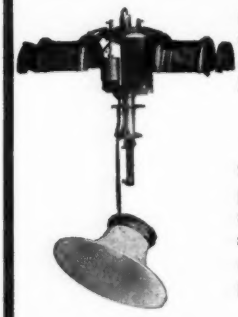

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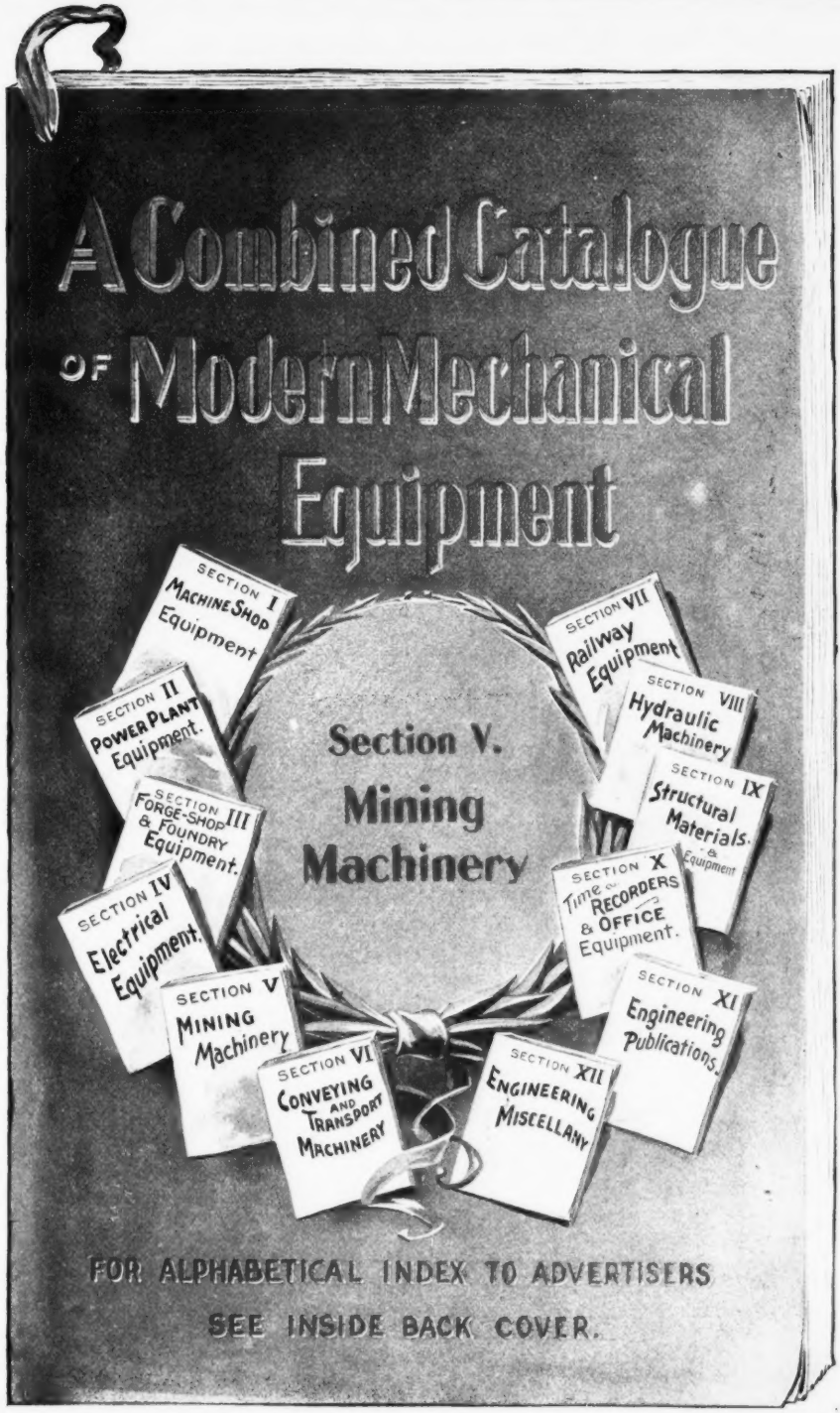

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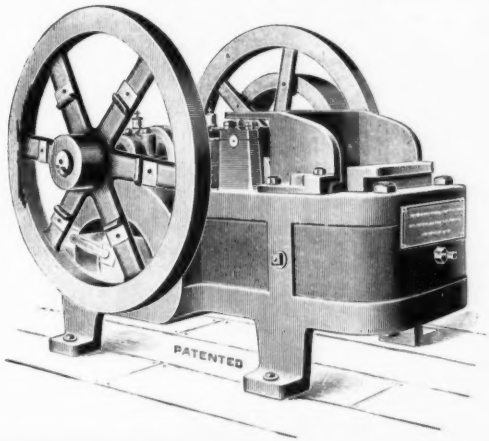

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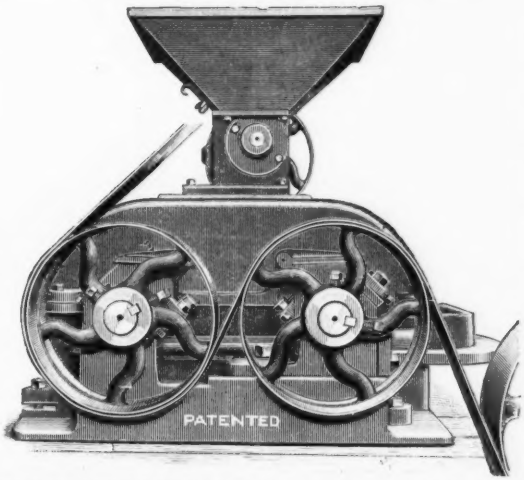

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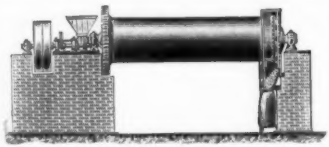

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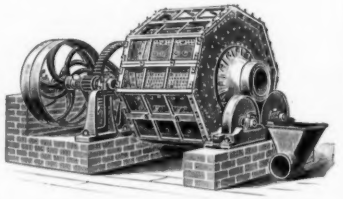

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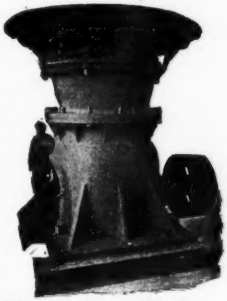

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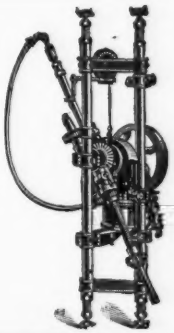

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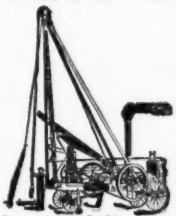

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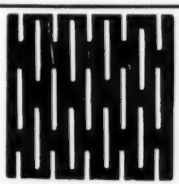

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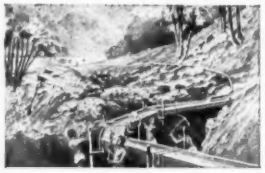

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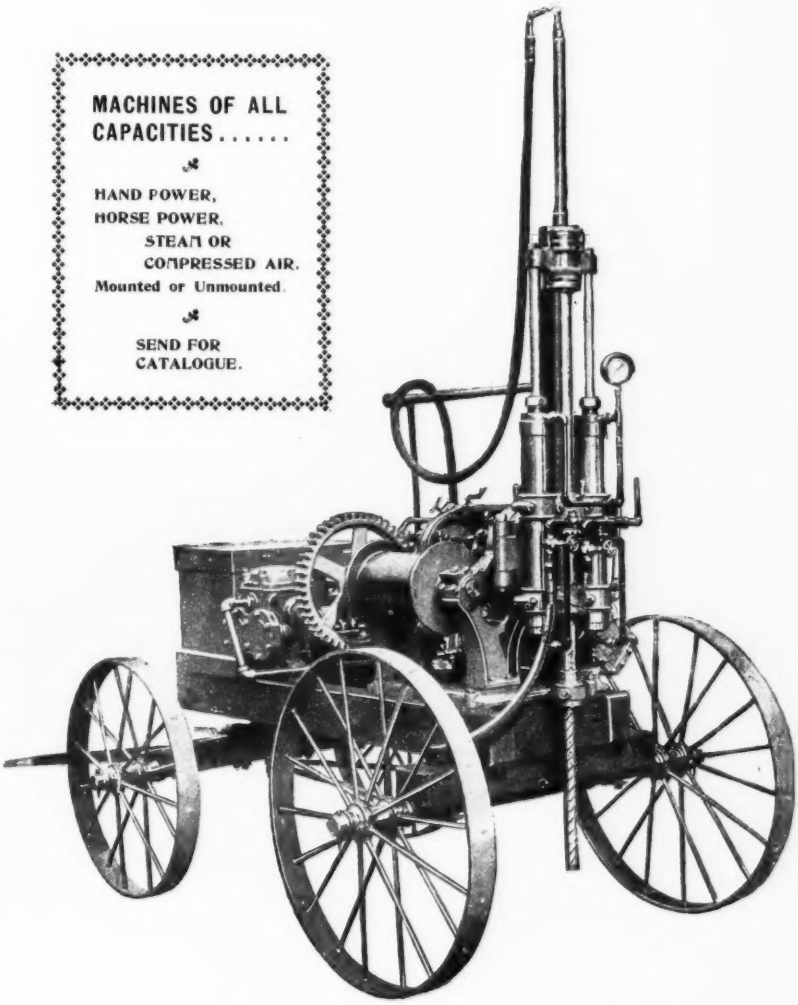

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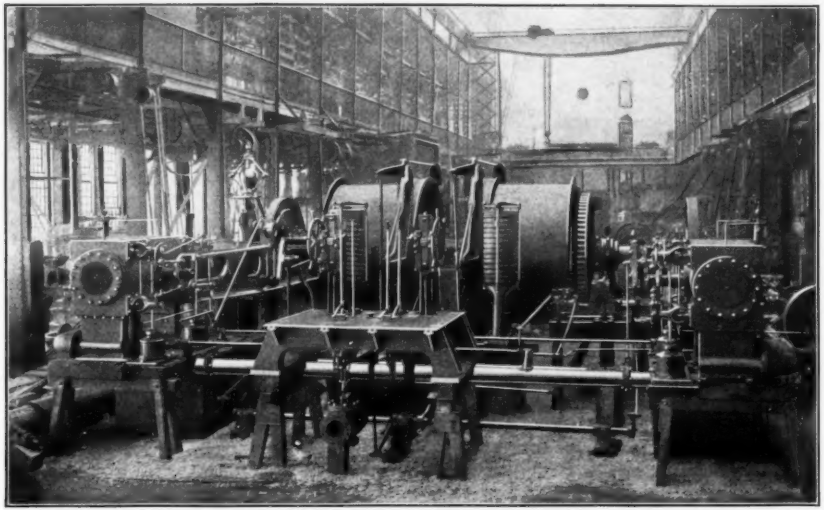

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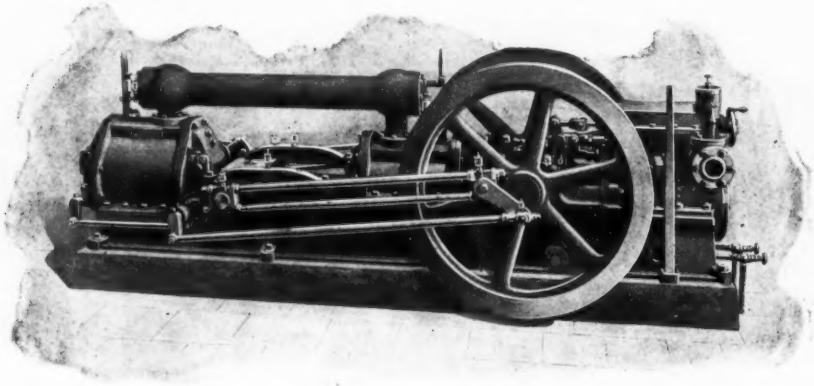

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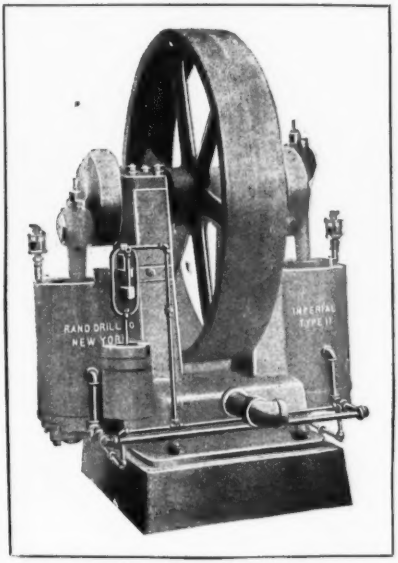

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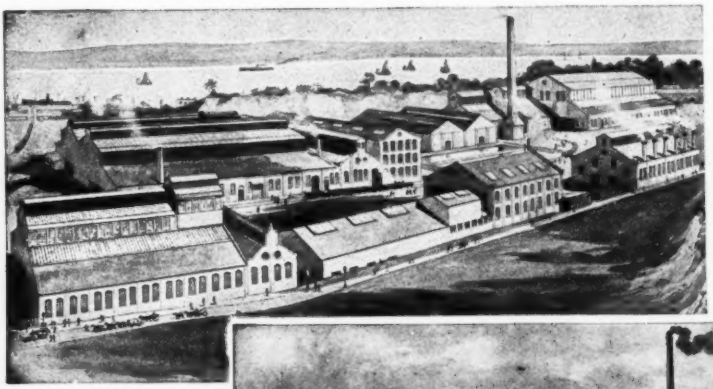

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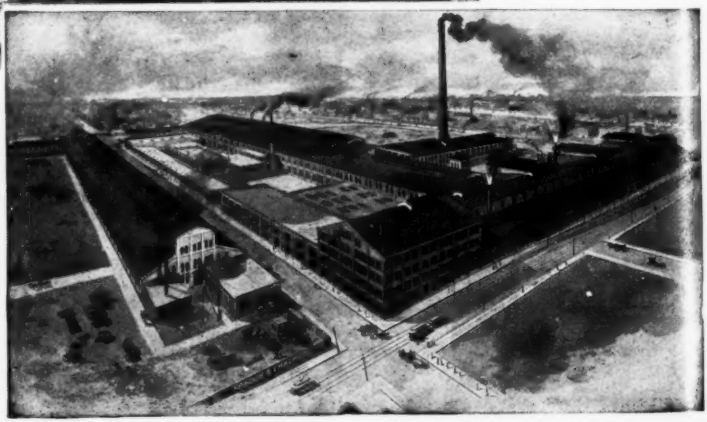

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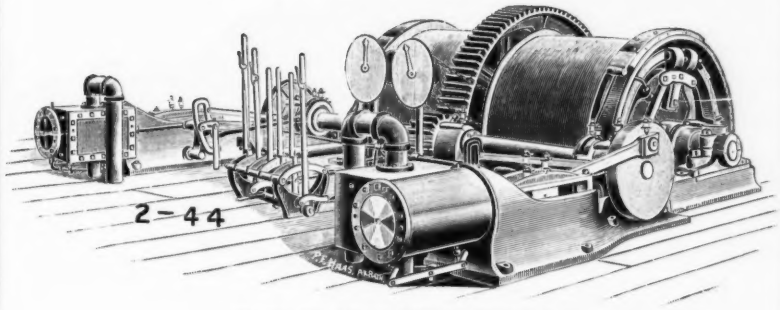

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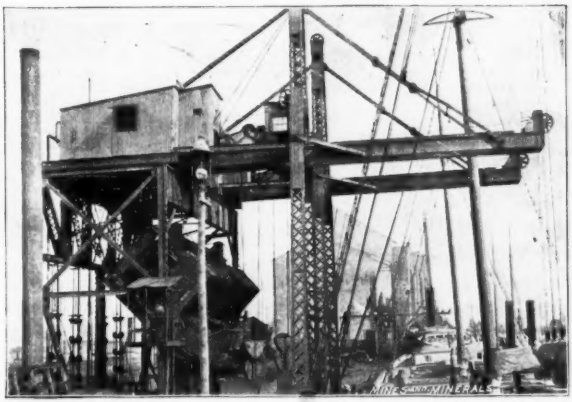

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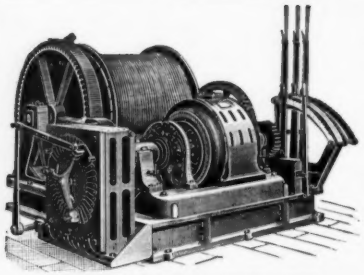

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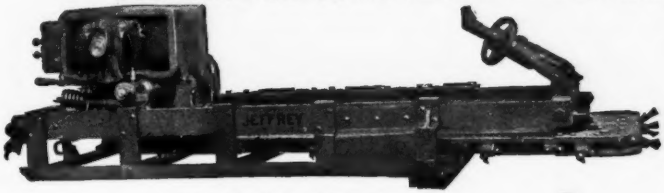

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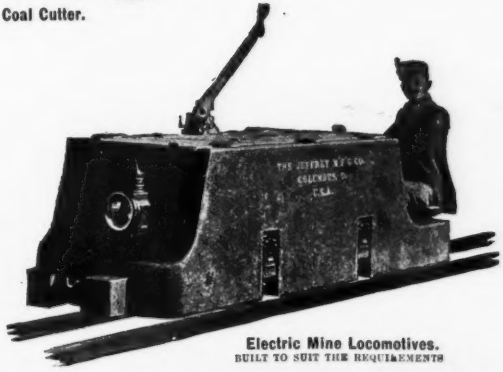

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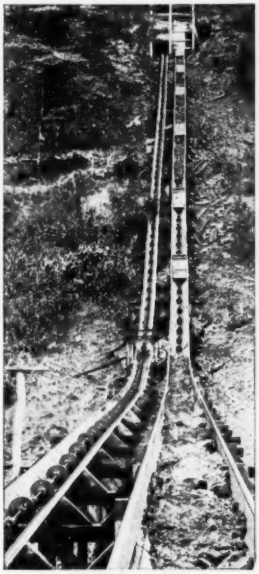

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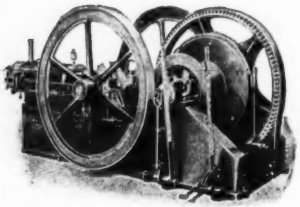

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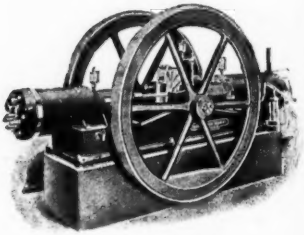

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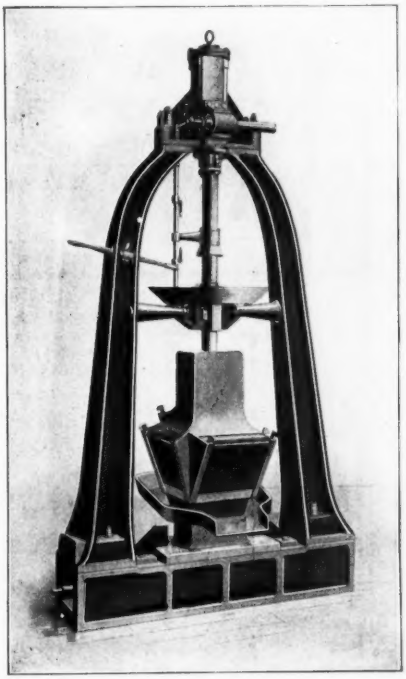

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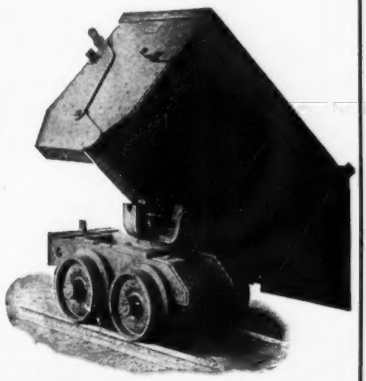

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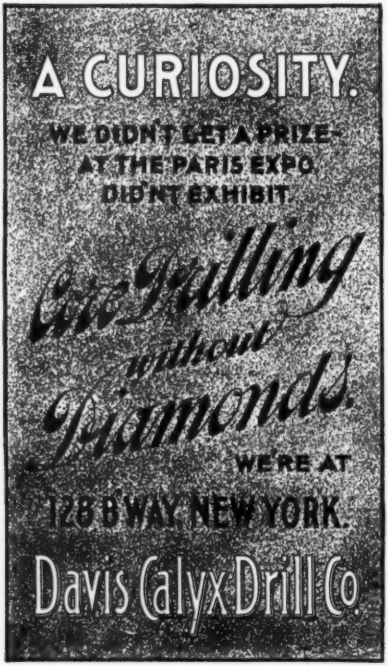

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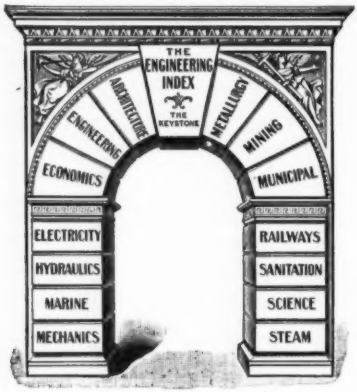

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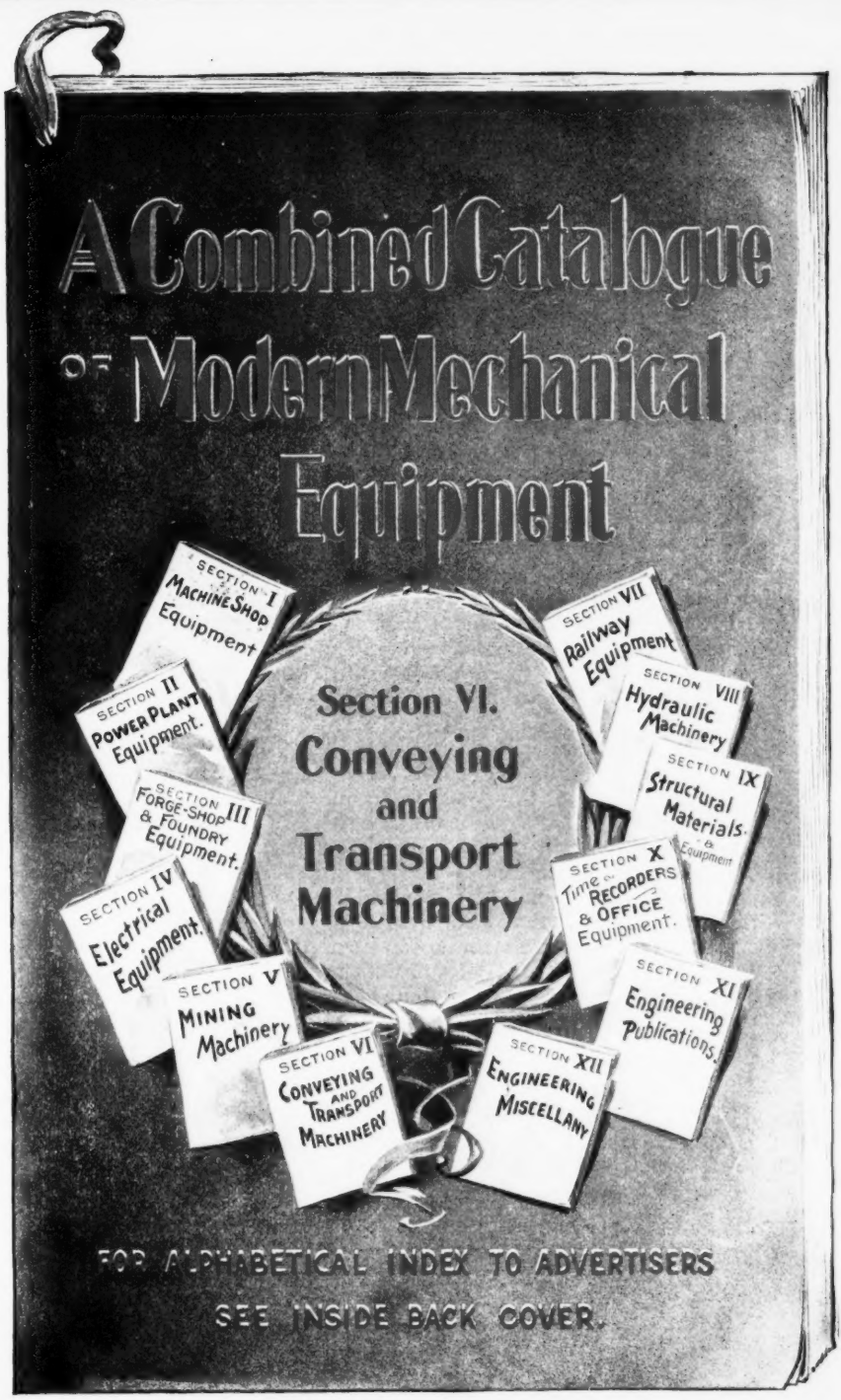
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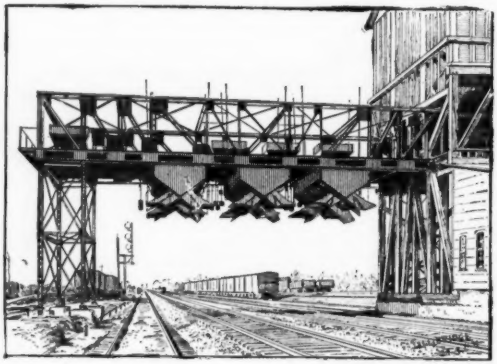

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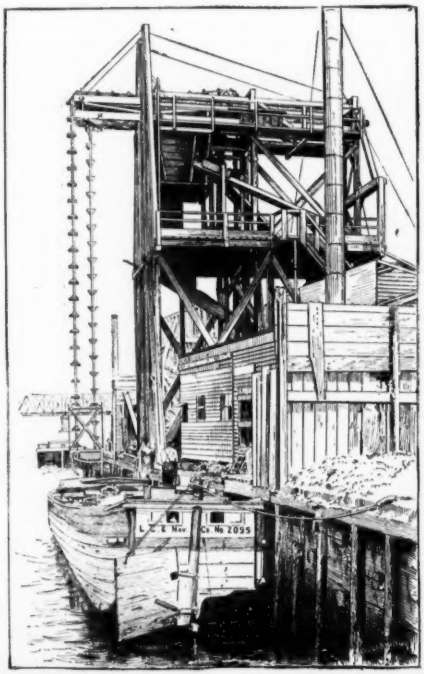

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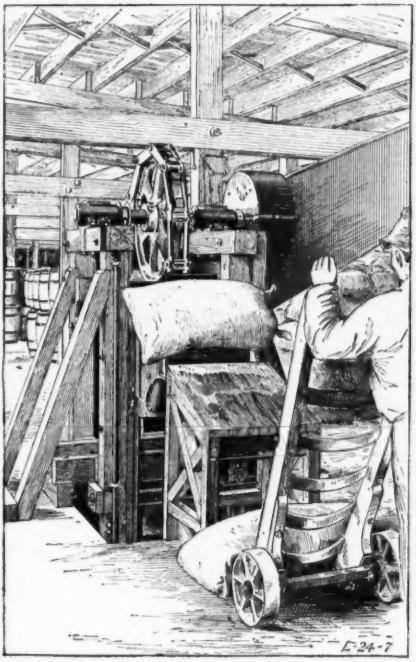

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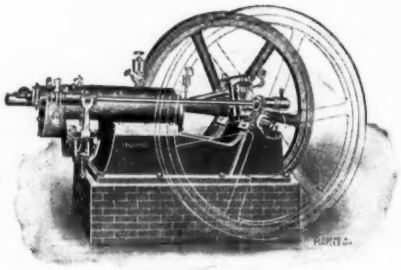

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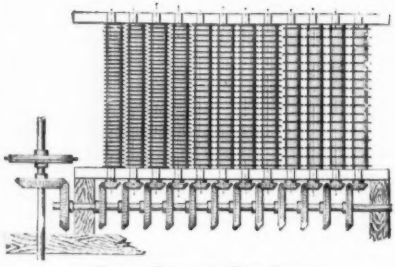

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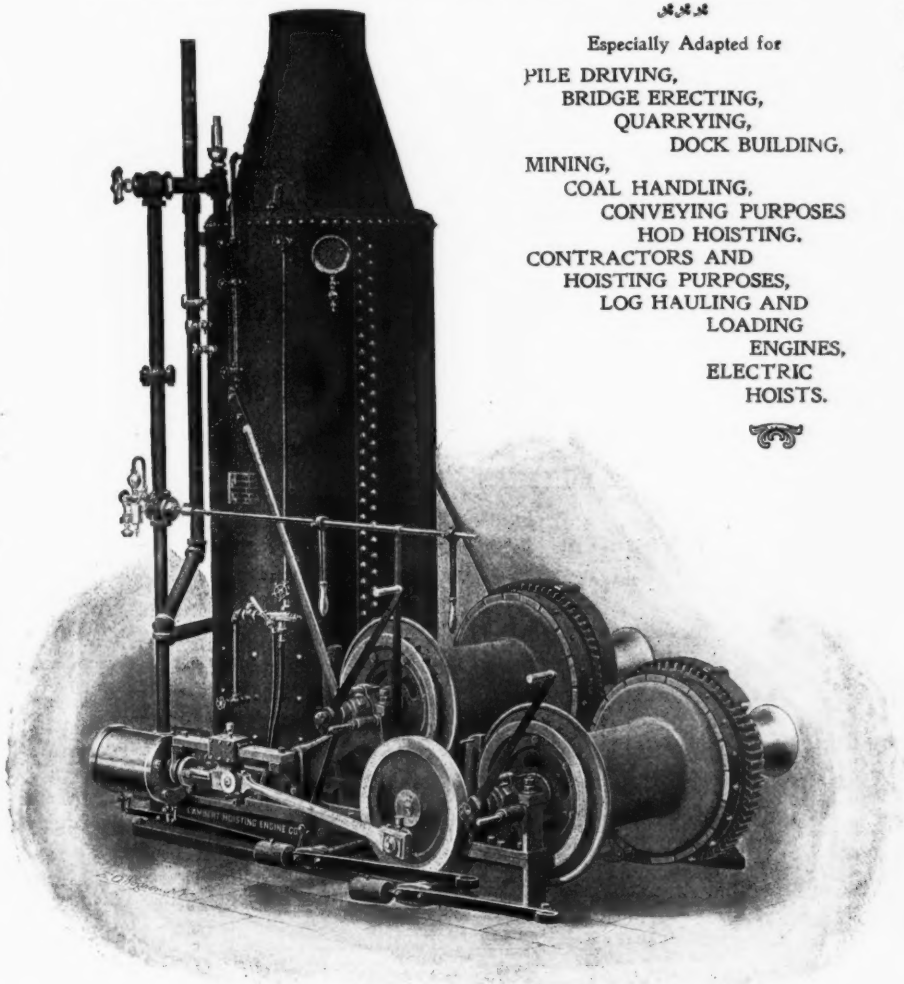

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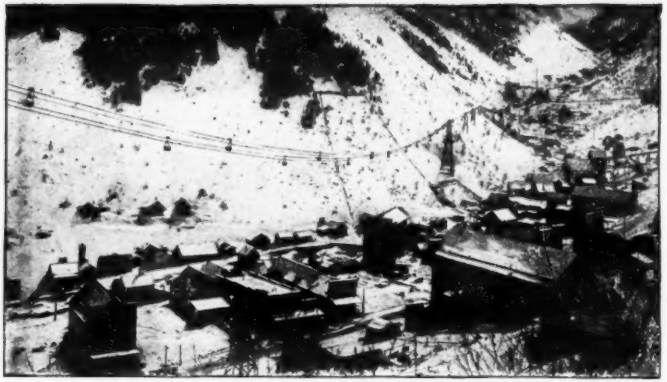

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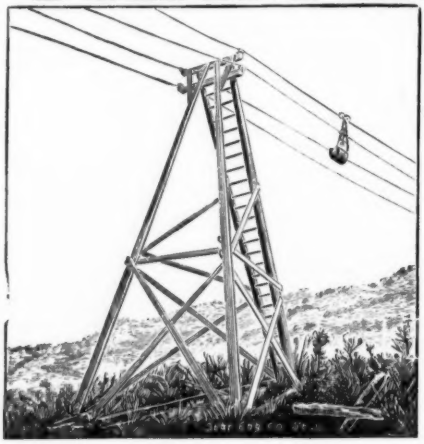

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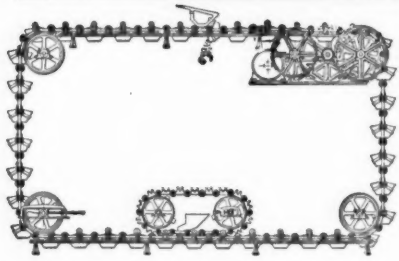

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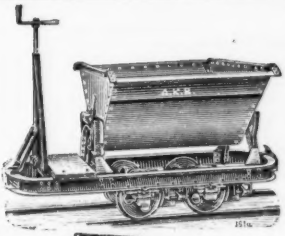

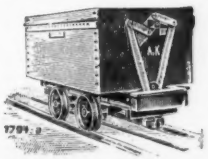

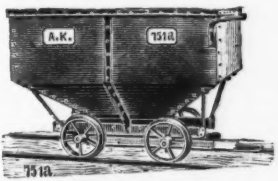

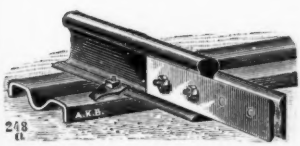

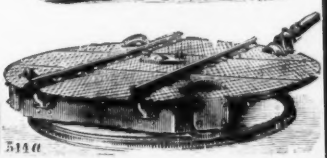

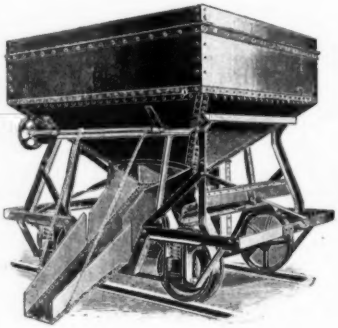

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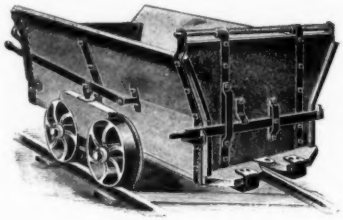

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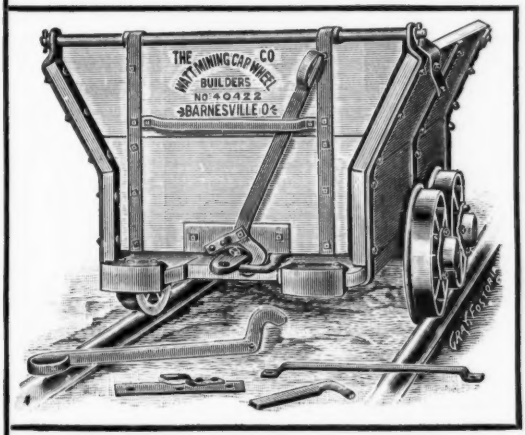

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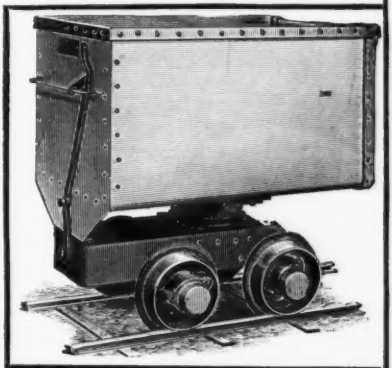

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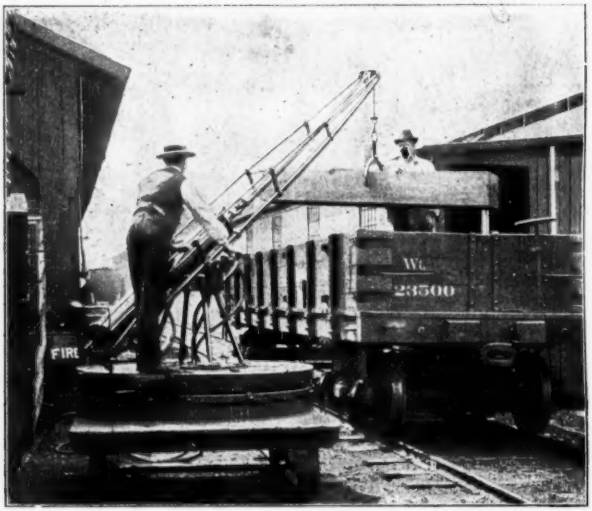

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Especially adapted to loading heavy material on cars or boats.
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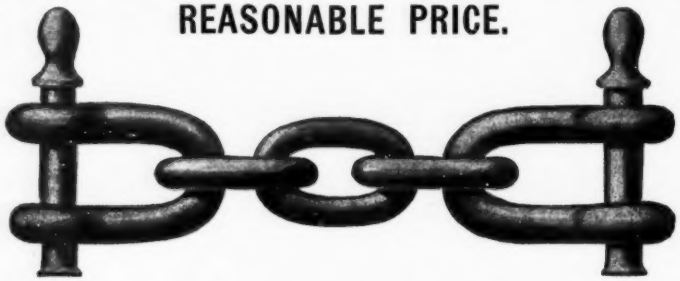

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It does not pay to make your own Hitchings. We can supply you better and cheaper. Send for Prices.

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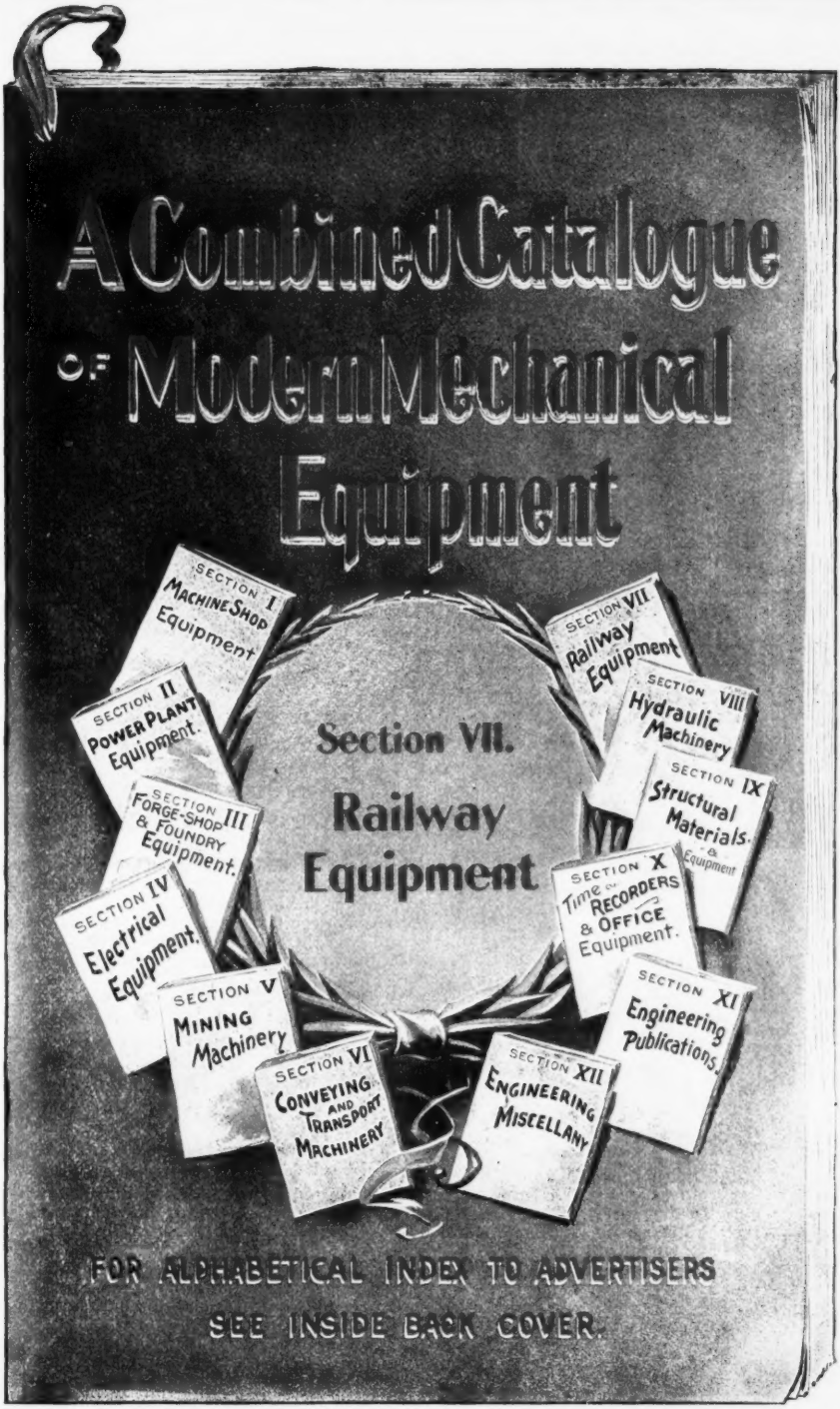
For other advertisements of Conveying and Transport Machinery, consult the Electrical, Mining, and Railway Sections



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What They Think of it at Home and Abroad

NEW YORK, November 8, 1900.

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Yours very truly,

THE INGERSOLL-SERGEANT DRILL CO.
W. L. SAUNDERS,
Vice-President.

GLASGOW, 16th March, 1900.
HOLM FOUNDRY, CATHCART.

The Editor, THE ENGINEERING MAGAZINE,
222-225, Strand, London, W. C.

Dear Sir:—We enclose herewith some coupons for items mentioned in the Index of your March number, and will be pleased if you will kindly forward us the articles in question.

We take the opportunity of asking when Mr. Roland's book on Cost-Keeping is to appear,* as this is a subject in which we are considerably interested. We must also congratulate you on the manner in which your Magazine is keeping up, and express how much we are indebted to the articles by Mr. Roland and Mr. Norris, and such articles as that in your present number on the Purchasing Department, by Mr. Hugo Diemer. Mr. Norris's and Mr. Roland's articles have been simply invaluable to us. The concrete character of the information and the actual examples given by Mr. Norris are exactly what the more progressive firms are looking for, and we trust to have a continuance of similar articles in the future. We are especially pleased to note that the Foundry Department will be dealt with shortly. We are, sir, yours faithfully,

G. & J. WEIR, Ltd.

Words of Praise from Germany

LEIPZIG-GOHLIS, den March 14, 1899.

THE ENGINEERING MAGAZINE, New York.

Gentlemen:—Having had a sixteen-year experience in the United States, I am glad to assure you that I have never read anything as much to the point as the third article on Machine-Shop Management in Europe and America, by Mr. H. F. L. Orcutt.

I hope Mr. Orcutt will publish his writings in some prominent German engineering journal, for the benefit of those who do not read English. It should be done, and I would personally ask Mr. Orcutt to do so if I had his address. Will you kindy forward this letter to him? Very truly yours,

(Signed) H. HAEBERLIN, Chief Engineer.
Adolph Bleichert & Co. (the great Wire-Rope Tramway inventors).

* This work is now published. See announcement in Section XI., Engineering Publications.

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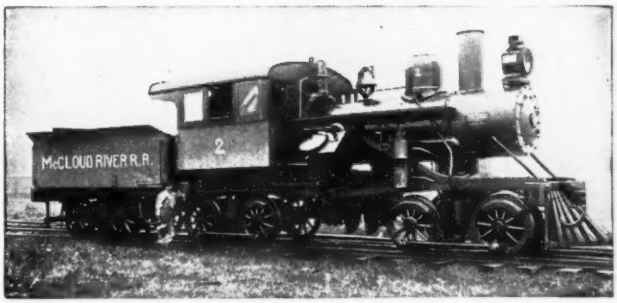

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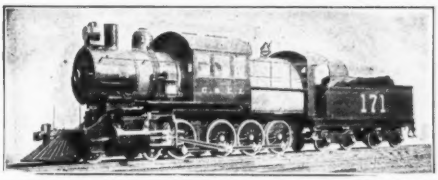

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Builders of Modern LOCOMOTIVES for all classes of service.

Light Locomotives for Contractors, Mines, Plantations, etc.

Compressed Air Motors. **See Page 6, Section V.**

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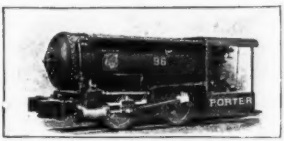

Compressed Air Locomotive, Class B P, No. 96.

LIGHT LOCOMOTIVES of all gauges of track, from three to forty-five tons weight, including special designs for mines, mills, furnaces, plantations, logging, contractors' use, passenger and freight service, suburban service, street railways and industrial establishments. **COMPRESSED AIR LOCOMOTIVES** for underground or surface work at coal, iron, copper, silver, gold and other mines, and for surface work where smoke or sparks must be wholly eliminated.

Locomotives, wide and narrow gauge, on hand.

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See Electrical Section, pages 1 to 8

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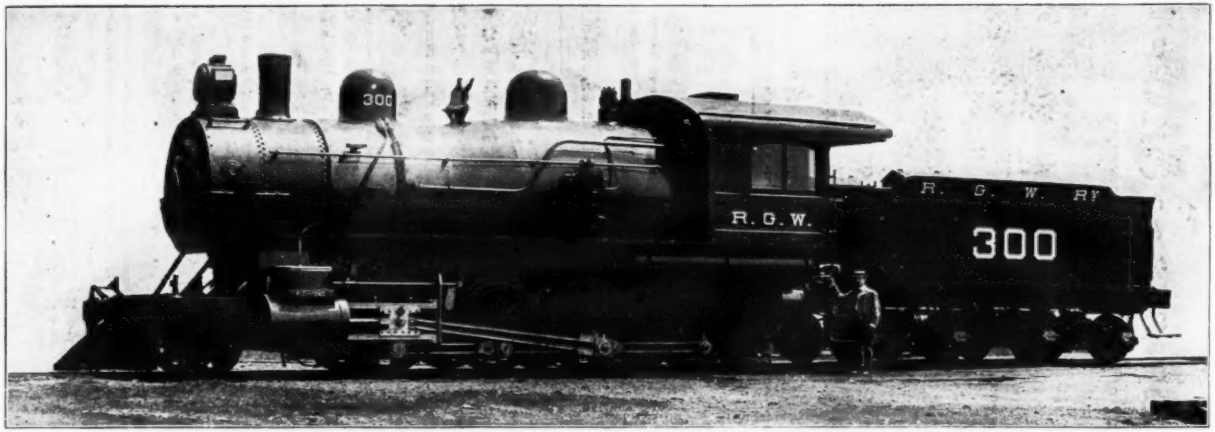

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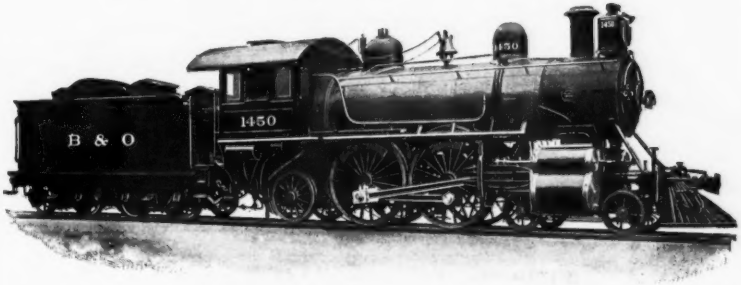

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Single Expansion and Compound Locomotives,

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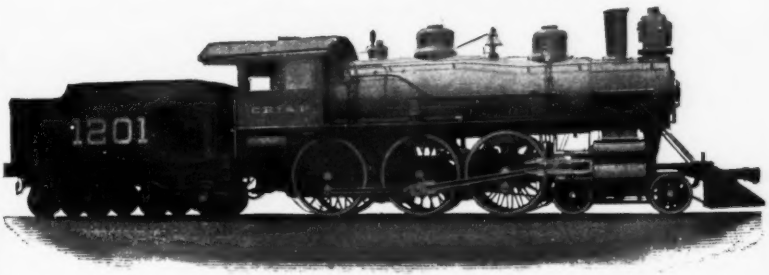

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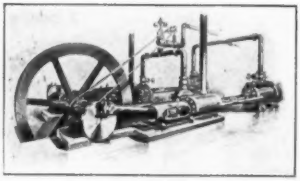

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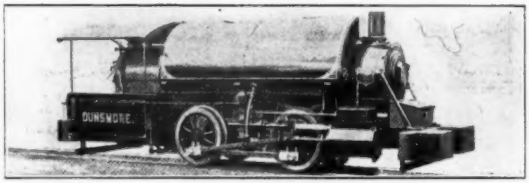

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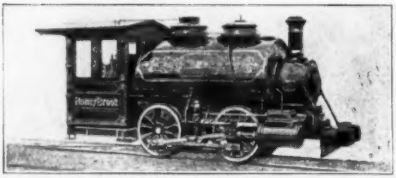

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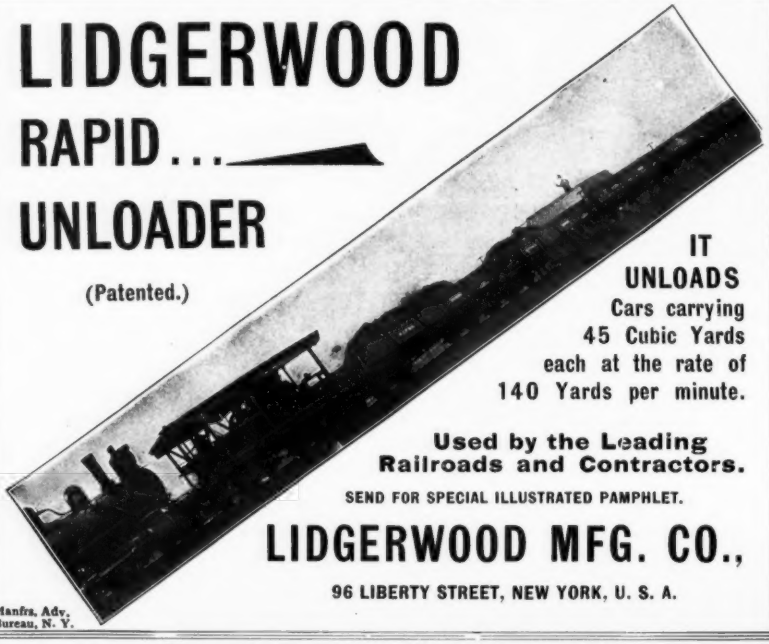
(Patented.)



IT UNLOADS
Cars carrying
45 Cubic Yards
each at the rate of
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Used by the Leading Railroads and Contractors.

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Built with open Crate or covered top. Cars leased only.

Controlling and Operating Patents for Dumping Cars, Vessels, Wagons, Barges, Bins, Trestles, Chutes, and the like.

Steel construction combined with malleable iron, especially adapted for discharging Ore, Coke, Coal, Gravel, Large Rock, Broken Stone, Pig Iron, Castings, Machinery, Loose Grain, Steel, Billets, Tin Plate Bars, Rail Ends, Hot Cinders, and many other similar materials by the gravity of the load alone without careening the car body.

Standard Running Gear—80,000 lbs. Cubic Capacity—Level load, from 32 cubic yards to 83 cubic yards.

SILVER MEDAL, PHILADELPHIA, 1899.
SILVER MEDAL, PARIS, 1900.

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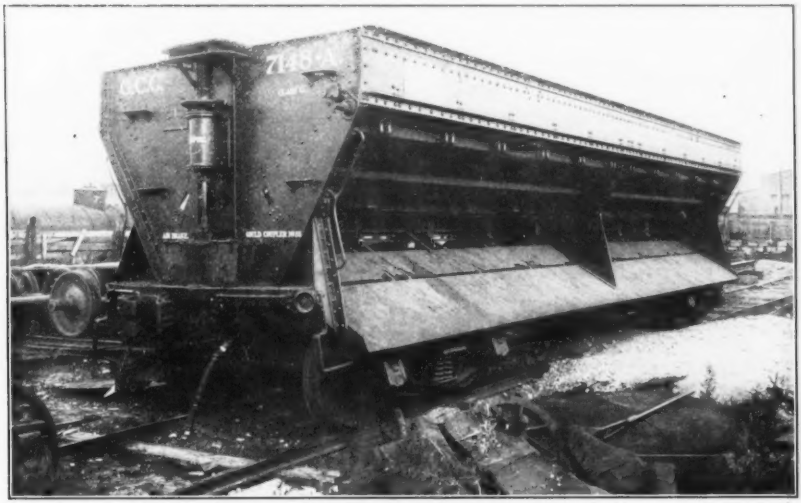

The special constructional, as well as dumping, advantages of the Goodwin Patent Steel Gravity Dumping Car over any other steel or wooden car in existence are:

1st. Their greater saving in the cost and time of transporting and unloading all dumpable materials.

2d. Their greater ability than any wooden car or other Steel Car to resist all crushing and pulling strains and all damaging effects from warping and bulging, caused by the excessive expansion and contraction from carrying either red hot or stiff frozen loads.

3d. The Goodwin Patents cover the only Steel or Wooden Cars built that dump either large or small material equally well, on either or both sides, or in the center, without careening the car or movement of the car body.

4th. They are the only cars built from which one man, while the train is in motion, can discharge the entire train load of large or fine material at the same instant by the aid of compressed air, steam or electricity, depositing the load either between the rails or outside or both, at the same time.

5th. They are the only cars built in which the freezing of a load of rock, coal, ore, or any similar material in the car does not materially interfere with the discharge of the load.

6th. They are the only cars ever built or patented that can be used equally well for the combined purposes of either the usual Hopper or Tip-Dumping Car or the Center or Side Ballasting and Filling Cars, or for handling and discharging all kinds of Way Freight and General Merchandise conveniently and economically, on level ground without trestles, using the gravity of the material alone as the unloading power.

Some further claims for the Goodwin Patent Steel Gravity Dumping Cars, which may be claimed for any other large capacity Steel Cars, if built on engineering principles, compared with general wooden car construction, are:

Cost of repairs reduced about 50 per cent. Increased ability to withstand rough usage, shocks and collisions. Less wear and tear on tracks and on cars. Longer life. Greater salvage value. Higher speeds attainable on rough and uneven tracks and on curves, due to special center plates and side bearings and to truck construction. Increased cubic as well as ton capacity. Greater percentage of paying load to dead load.

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...Westinghouse Air Brake Company...

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21½ inch Gauge. For Manufacturing Establishments.
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Complete Equipments always carried in stock, ready for immediate delivery.

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Arthur Koppel.

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For Coal Handling and Construction Work.
See Section VI., Page 16.

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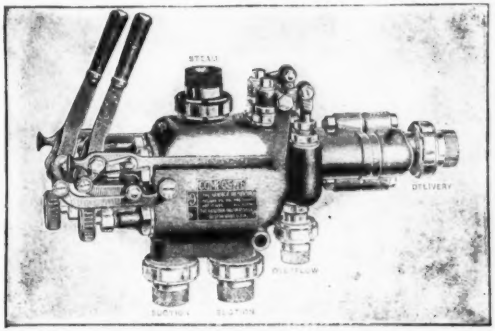
The Hancock Inspirator

"COMPOSITE" TYPE.

FOR

Locomotives.



The COMPOSITE is a Compound Hancock Inspirator, consisting of two separate and individual Inspirators within one body, operated either separately or simultaneously.

Where it may be desired to locate BOTH INJECTORS ON ONE SIDE OF THE LOCOMOTIVE convenient to either the engineer or fireman who has charge of pumping the engine or on the boiler butt available to both, the advantages of the "COMPOSITE are apparent.

Its use saves expense for the pipe connections and main steam and check valves that are otherwise necessary when two injectors are used.

Our Railroad Catalogue "B" gives full particulars and will be mailed FREE upon application

The Hancock Inspirator Co.

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Kyanized Lumber.

If you are not familiar with the process and its uses, send a 2c. stamp for our beautifully illustrated pamphlet on "The Artificial Preservation of Timber." It will give you a great deal of information on the subject.

The process of Kyanizing has a test of more than fifty years of actual practice back of it. You cannot afford to neglect its use.

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We shall be pleased to hear from you; we have facilities for handling your work.

We can make for you on short notice large or small castings in Brass or Bronze, from Blue Prints or Sketch. Patterns furnished at no extra charge.

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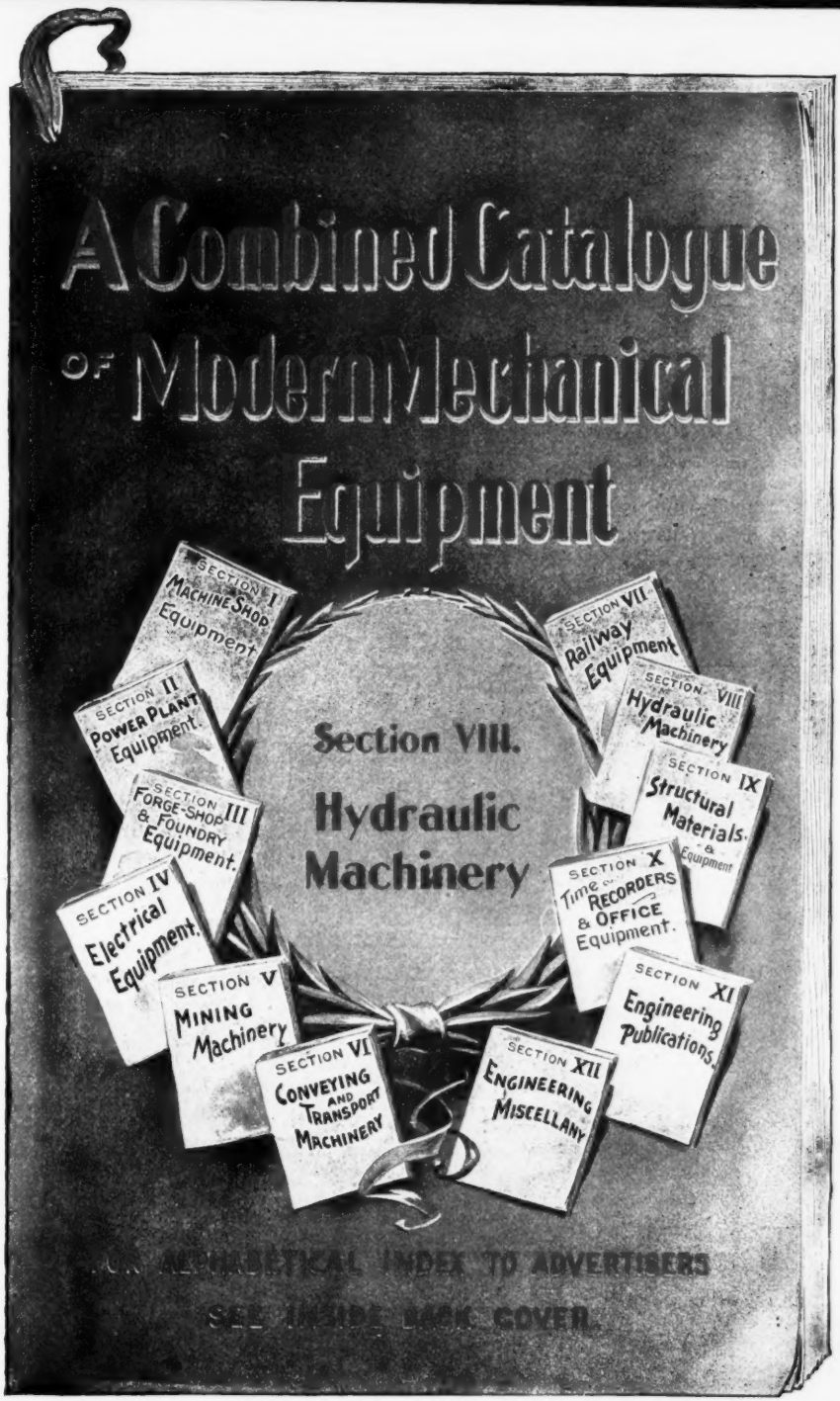

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Attempts at indexing engineering literature have been innumerable. But this is the first time that such a work has been carried past the point of theory to that of actual usefulness and practical value. For we not only indicate the character and purpose of every important engineering article published in any part of the world, but we actually supply the article itself if that be desired.

For these reasons the special attention of active engineers, and busy men in all lines of industry, is asked to the careful explanation of the whole system which is given in this number under SECTION XI., ENGINEERING PUBLICATIONS.

NOW IN PREPARATION

Volume III. of The Engineering Index—Covering the five closing years of the XIX. Century—Embracing in one volume of over 1,500 pages the past five years' work of THE ENGINEERING MAGAZINE Staff—Alphabetically arranged by subjects—Making promptly available every article published during the period—The most important work of the kind ever published—And making a distinctly new era in the development of practical systems of indexing engineering and mechanical literature.

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Upon the following four pages are illustrated a few of the various types of steam pumps manufactured by the A. S. CAMERON STEAM PUMP WORKS.

To thoroughly try the good qualities of a steam pump and seek out every defect, there is no better proof than the test of mine work. Below ground a pump is generally placed and connected up as best it can, not as it ought to be, and, while receiving scant attention and many hard knocks, it must work steadily and faithfully, with a minimum chance of breakdown.

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We invite your attention to our "Sierra" and "Mountain" patterns Vertical and Horizontal Plunger pumps, illustrated on pages 2 and 3, cut in sections of not over 300 lbs. weight for mule back transportation They have found their way over mountain passes into every mining region of Central and South America.

We strongly recommend our pipe pattern plunger pump, illustrated on page 3, for handling water strongly impregnated with sulphuric acid. This form of iron cylinder is far less costly than a water end of solid bronze, and its different sections when eaten away may be renewed, and the whole cylinder is not ruined by the corrosion of any part.

On page 4 is illustrated our combined pump and boiler for railroad tank service, many of which are used by railroads throughout the country.

The CAMERON regular pattern and power pumps are illustrated on page 5; these types of pumps are used for boiler feeding and general service.

There are now on the market various imitations of the CAMERON, some advertised under fancy names, some as the "CAMERON PATTERN" all exploited as "just as good as" or "just like" the CAMERON. To those who appreciate the possible disaster caused by a defective mining pump, we respectfully recommend the genuine, not only on the score of superior workmanship and material, and recently patented improvements, but because of our nearly forty years of experience, of which you get the benefit.

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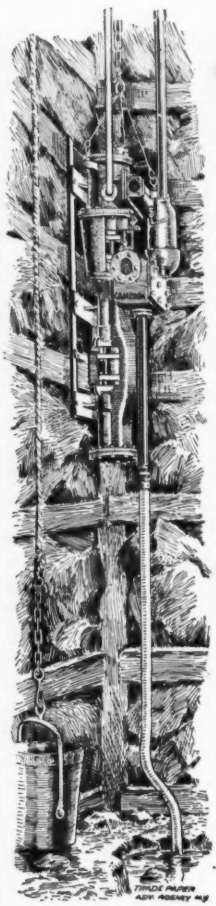
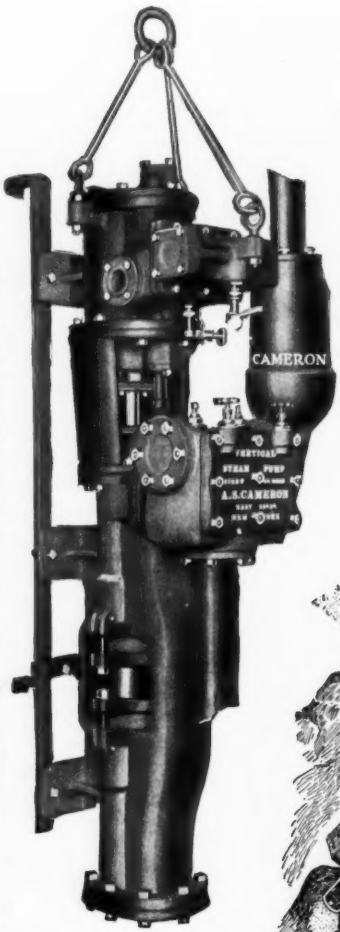
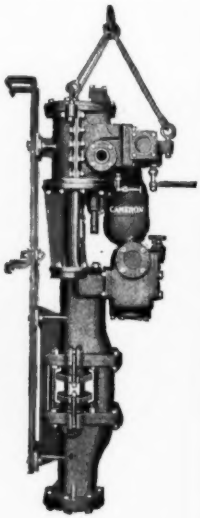
CAMERON

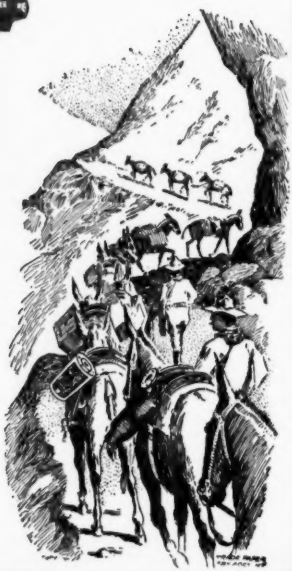
MINING PUMPS.

Sierras Pattern.
Sectionalized.







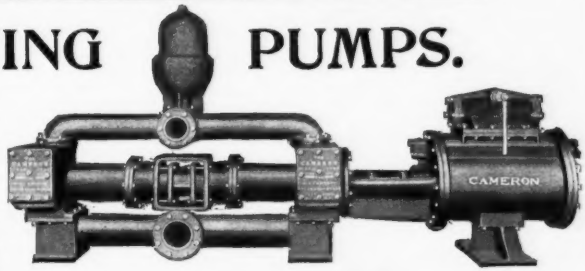


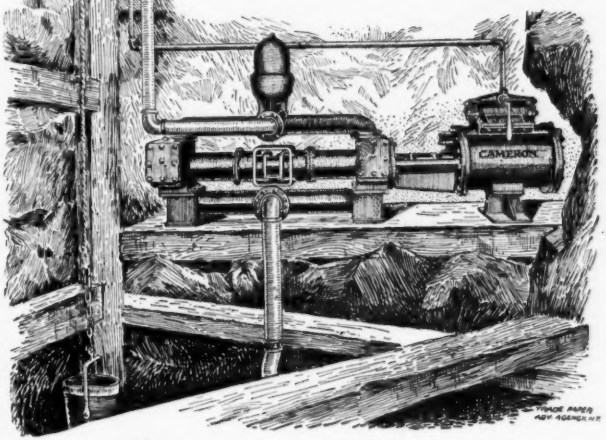
Vertical Plunger
Sinking Pump.

See Page 1
for Descriotive Matter.

CAMERON

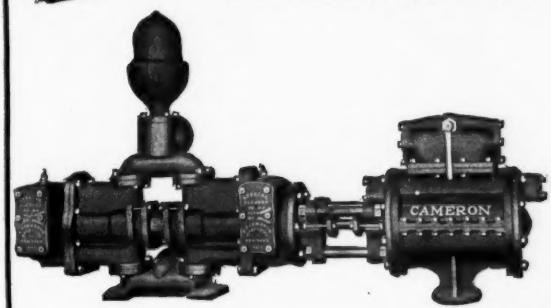
MINING PUMPS.





OUTSIDE PACKED PLUNGER STATION PUMP.

PIPE PATTERN.



MOUNTAIN PATTERN
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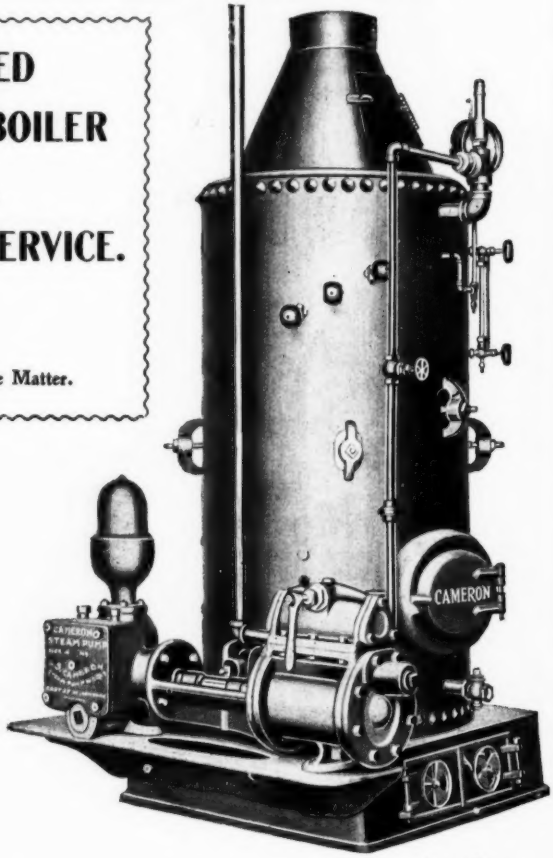

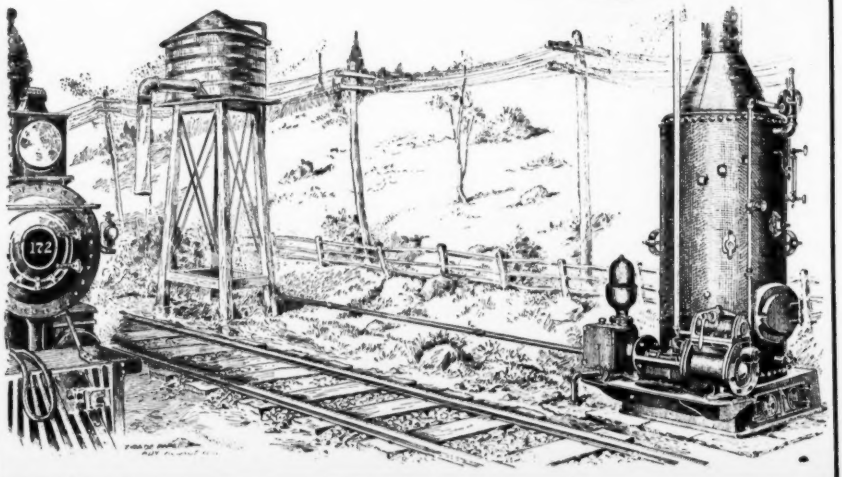

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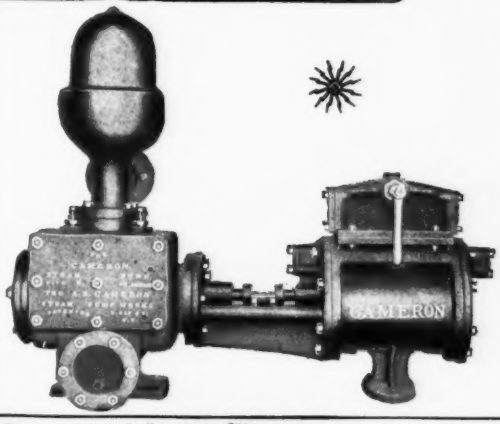
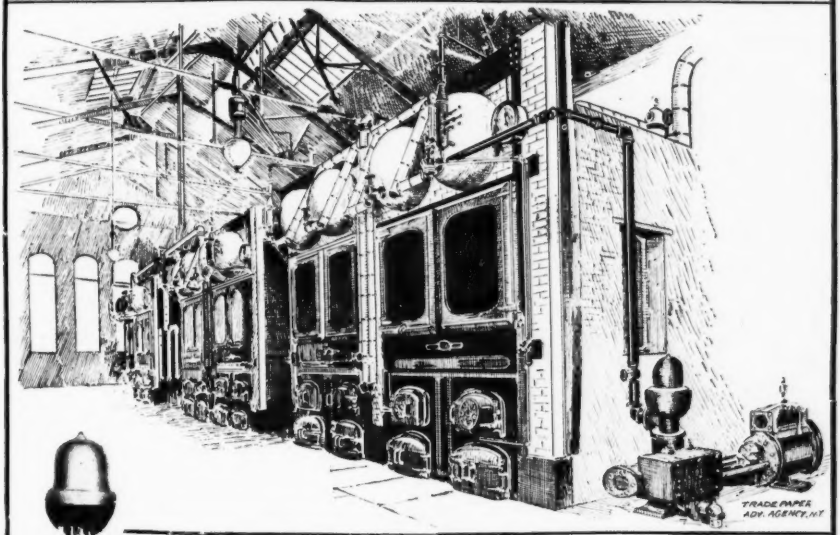
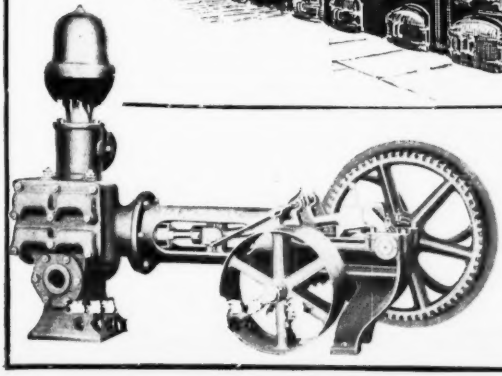
FEED PUMPS for BOILERS and for . . . GENERAL SERVICE.

REGULAR PATTERN.







POWER PUMP.

See Page 1 for Descriptive Matter.

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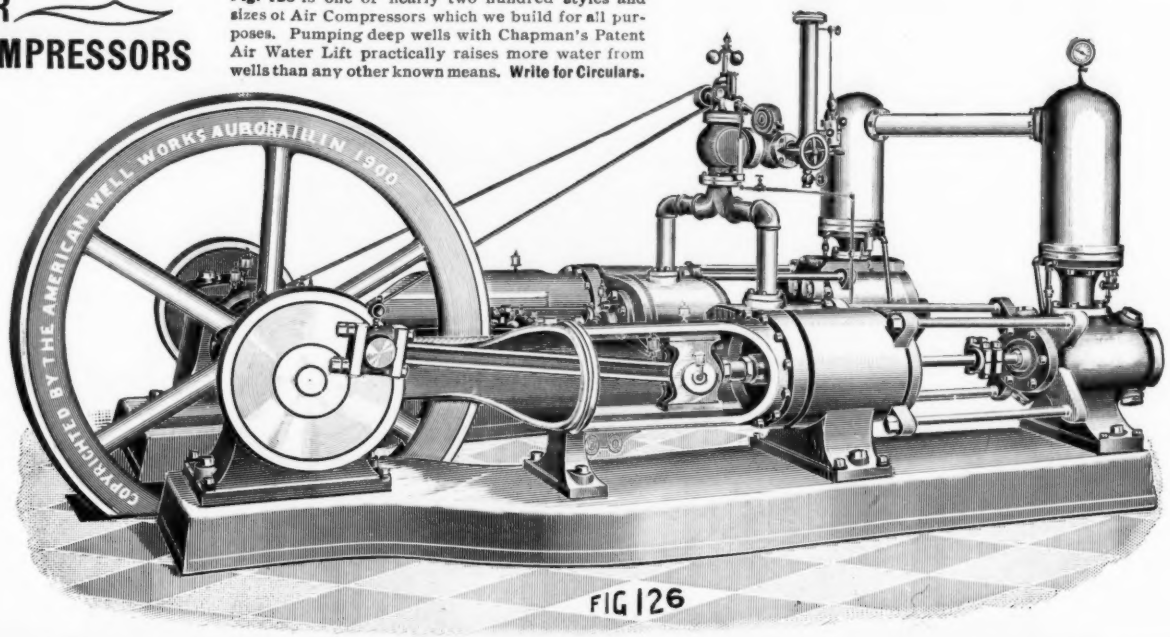

FIG 126

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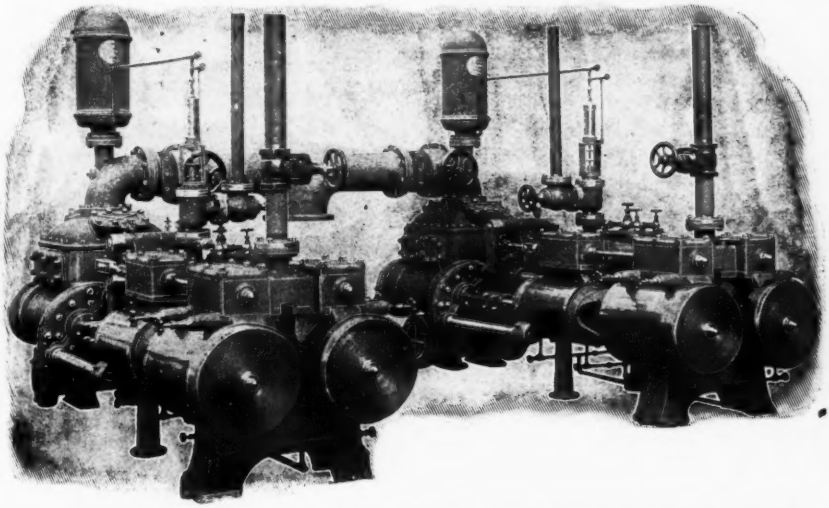

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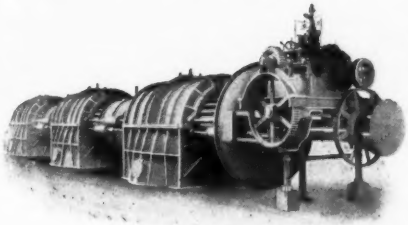

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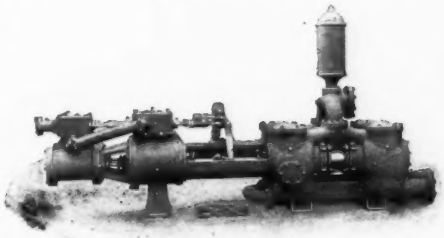

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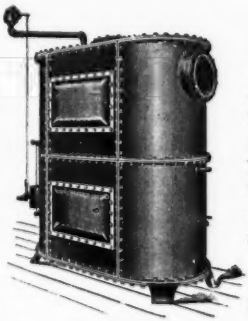

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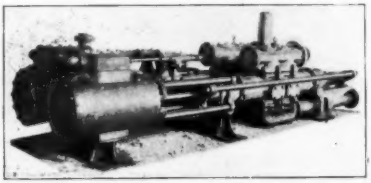

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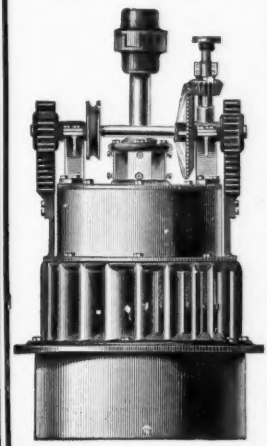

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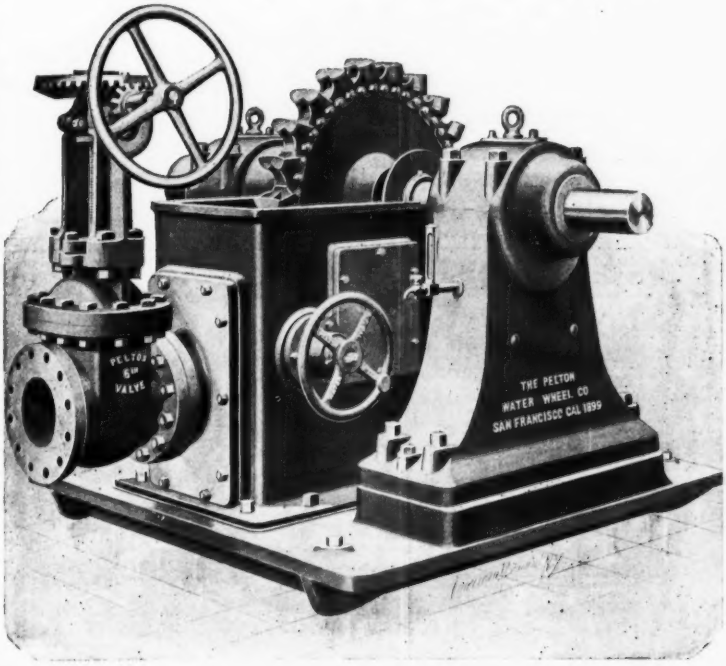

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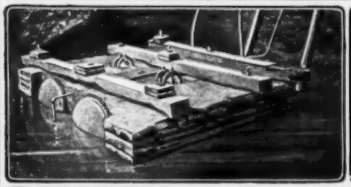

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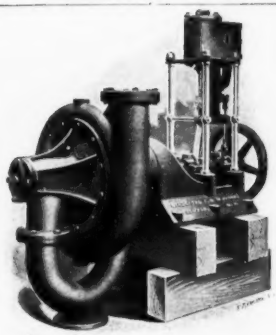

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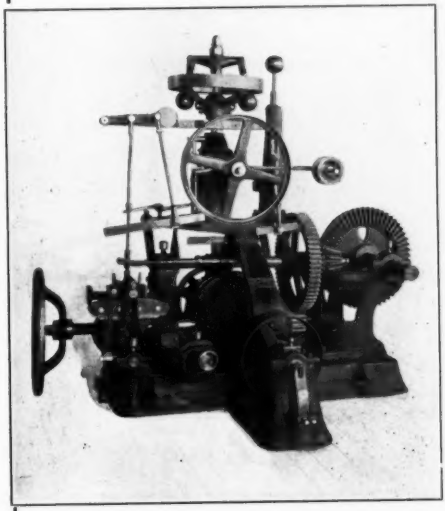

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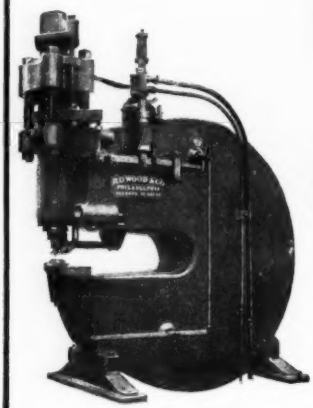

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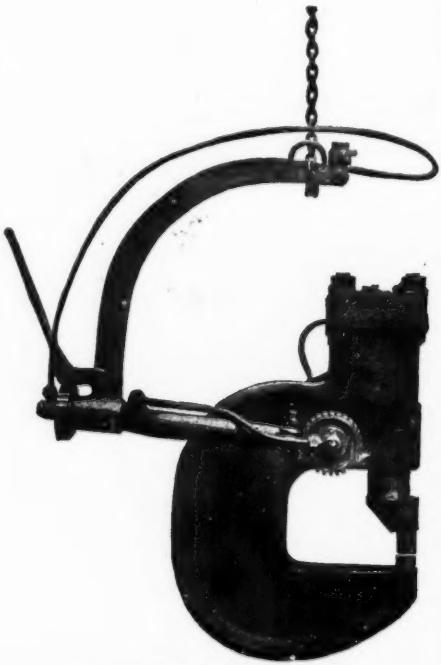

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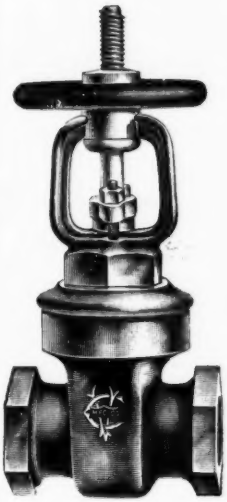

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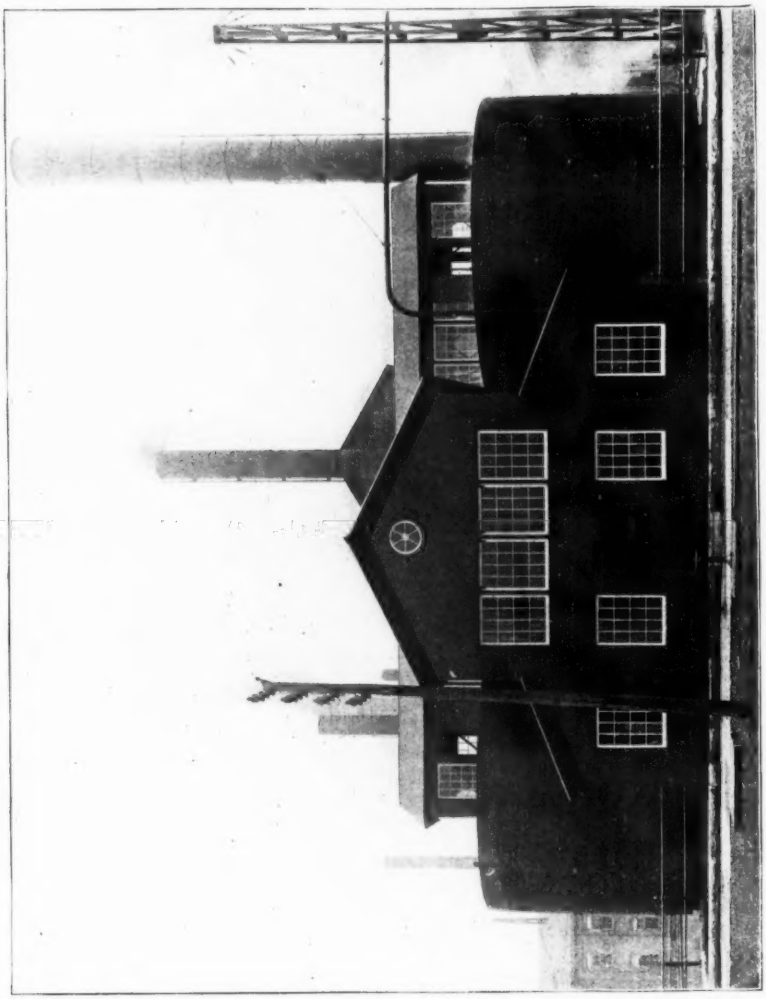

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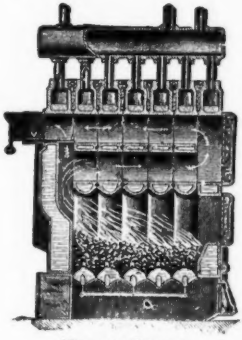

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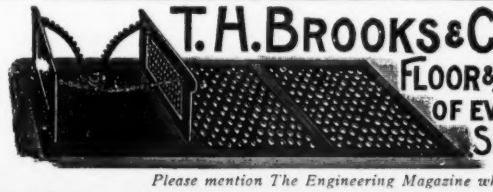

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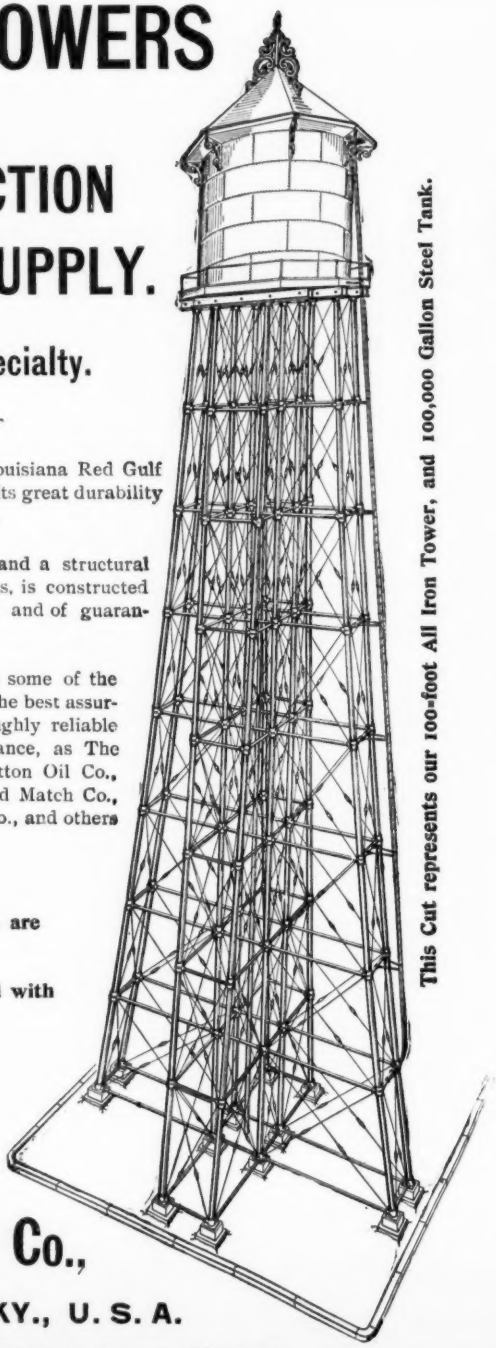

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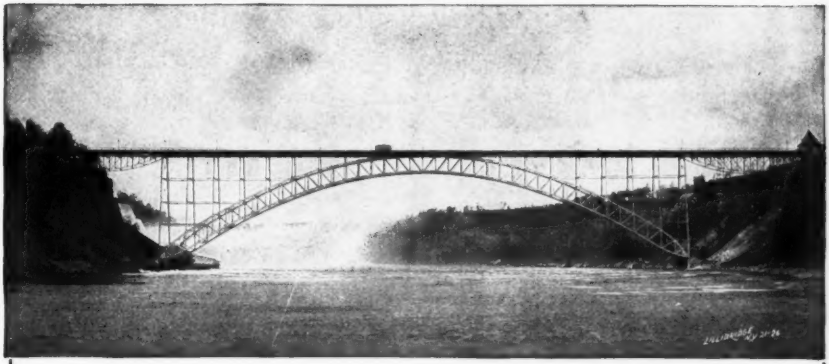

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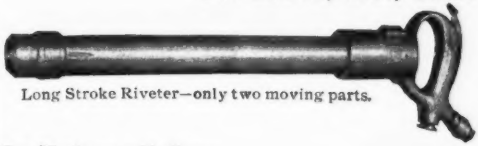

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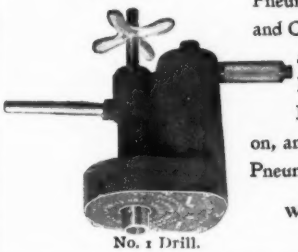

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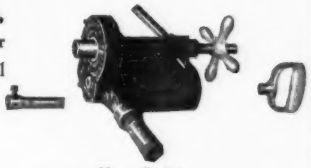

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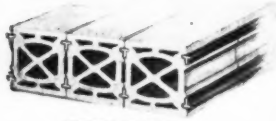

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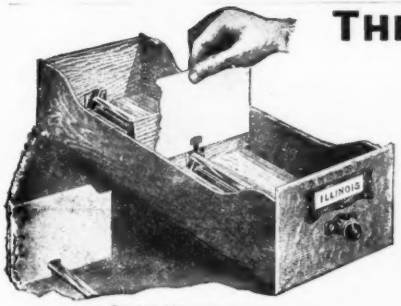

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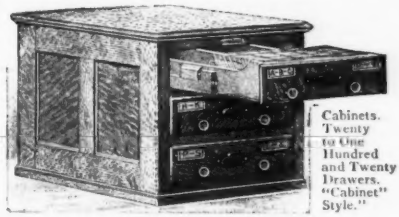

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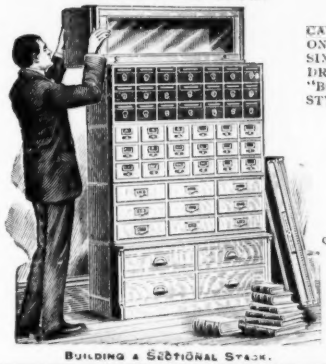

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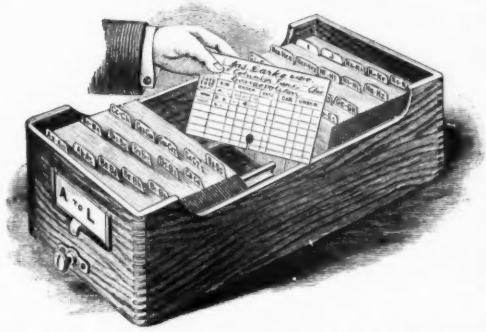

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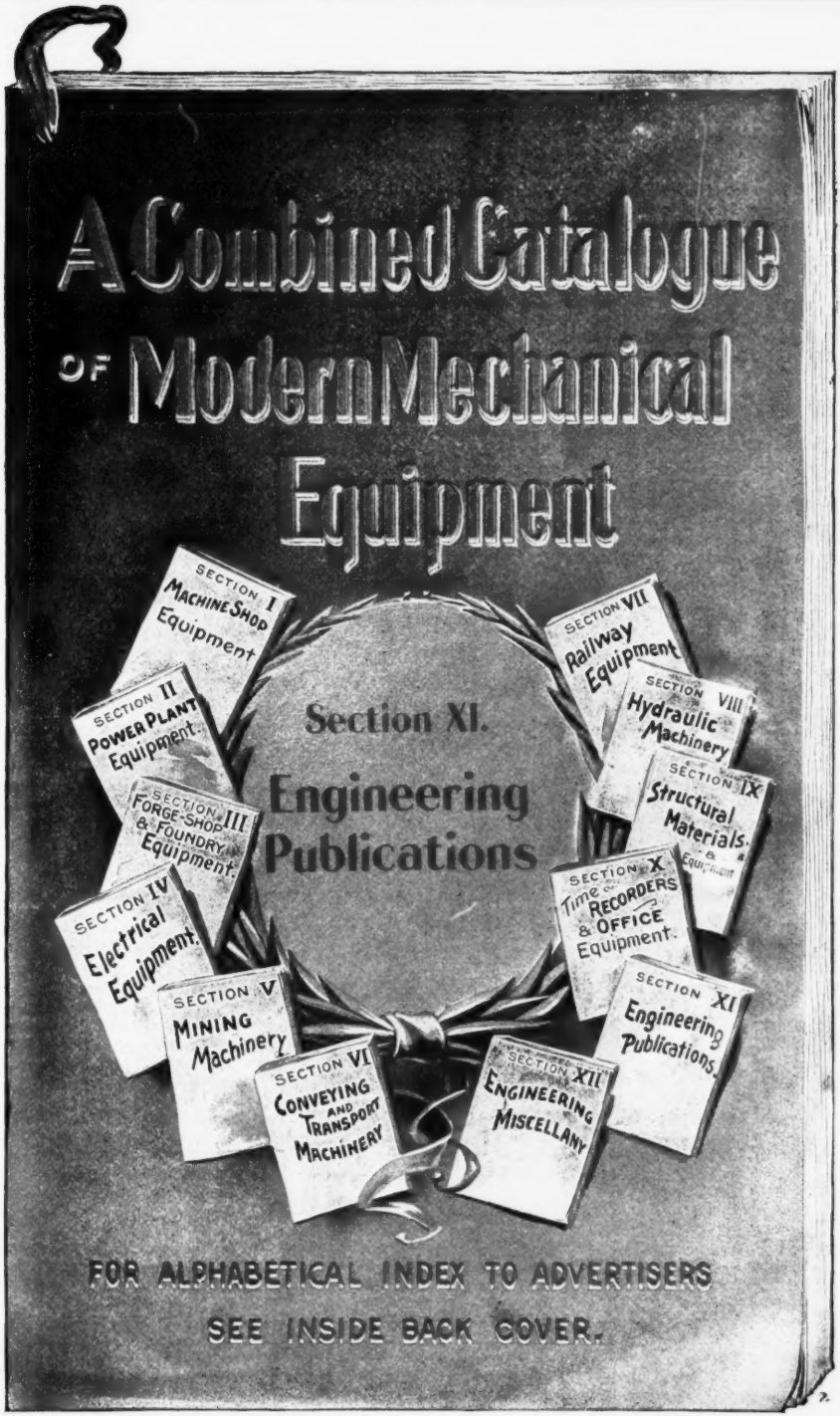

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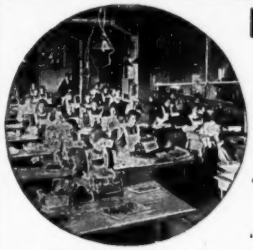

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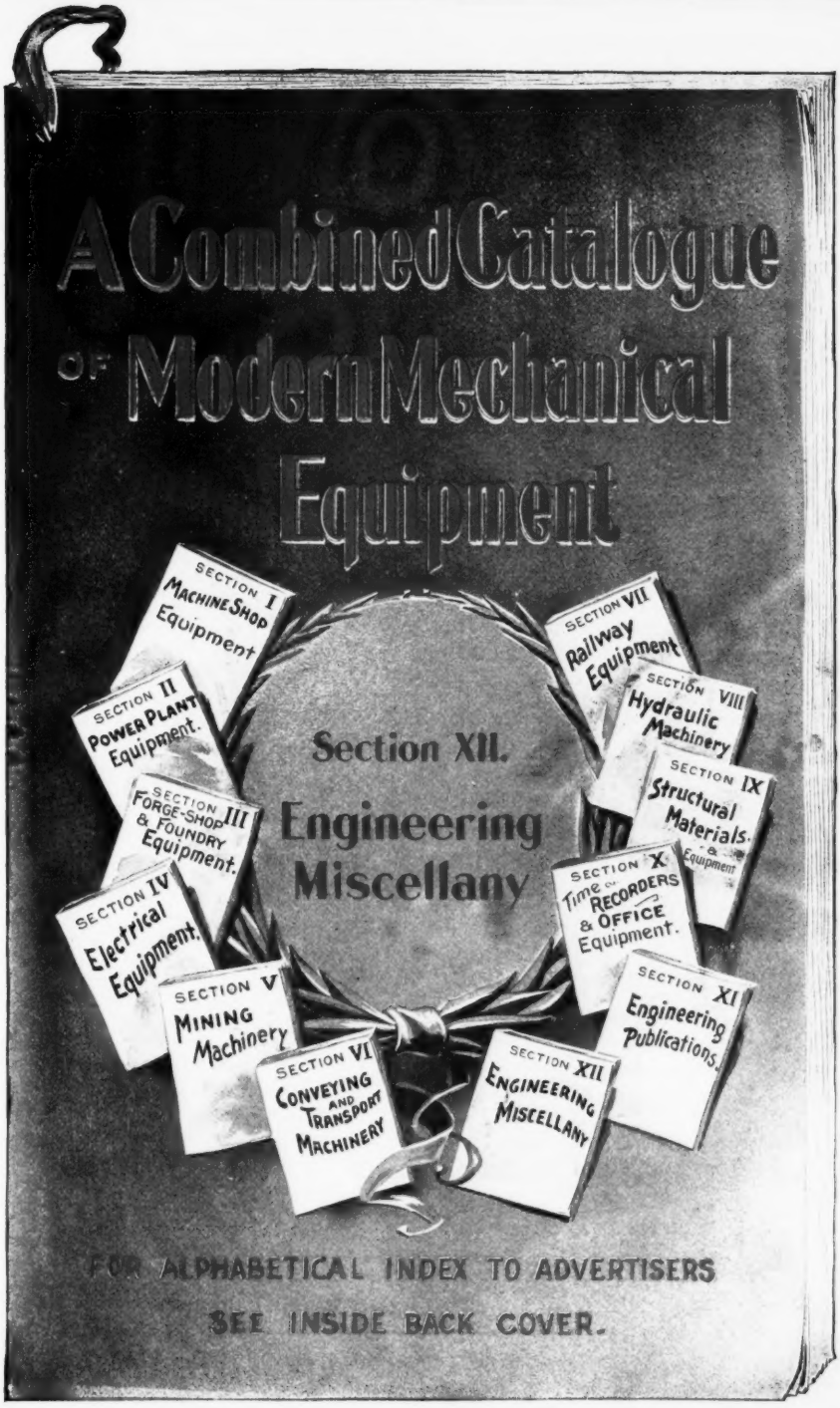

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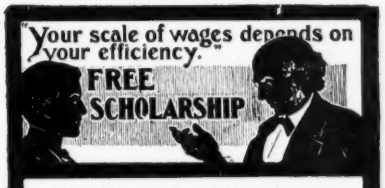

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FIG. D-13.

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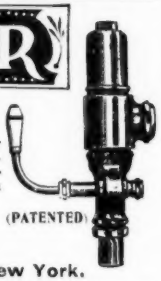

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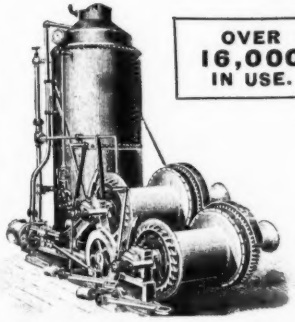

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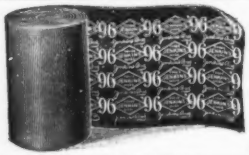

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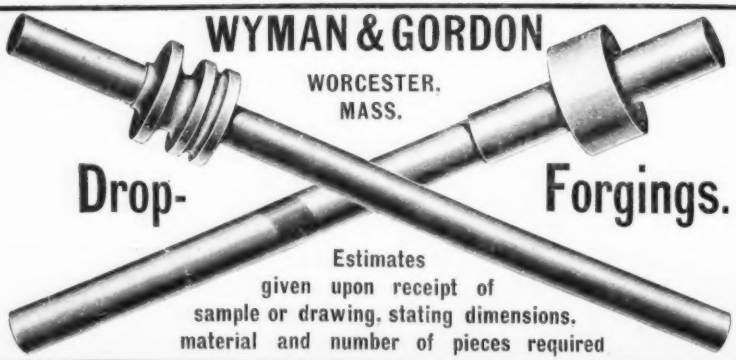

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